MACHINA

O2-T1: MACHINA curriculum outline

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Version 1.0	03/09/2021	Initial document		GEEKS
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ACRONYMS AND ABBREVIATIONS

ML Machine Learning

AI Artificial Intelligence

DL Deep Learning

E-CF European e-Competence Framework

EU European Union

EQF European Qualification Framework

ICT Information and Communications Technology

I-VET Initial Vocational Education and Training

M. Sc. Master of Science

MOOC Massive Open Online Course

NN Neural Network

OER Open Educational Resources

VET Vocational Education and Training

1 INTRODUCTION

The project's second Intellectual Output includes the development of a modular curriculum structure (syllabus) drawing on labour market analysis and skill needs evidence (O1) to be used by VET providers and employers for training ICT workers in Machine Learning (ML) methods, techniques, and practical applications.

The partnership has opted for a learning outcomes approach in the curriculum design, as recommended and detailed in CEDEFOP's European handbook on "Defining, writing, and applying learning outcomes", with clear references to the appropriate EQF level. This approach will help to achieve a better match between labour market skill needs and VET provision, and facilitate the recognition of relevant skills across the EU.

The first step towards the creation of the curriculum comprises the clustering of the defined learning outcomes (O1-T4) into self-standing, modular learning units along with the definition of unit specifications (learning objectives, weighting of outcomes, credits, prerequisites, assessment criteria) according to ECVET principles.

Each learning unit will be designed to consist of a unique set of learning outcomes, defined in terms of knowledge, skills and competences, which can be assessed and validated in a consistent and coherent approach. Each unit will be also assigned with ECVET credit points to serve as a point of reference for a future, accredited qualification on Machine Learning for ICT professionals.

This report defines the structure and specifications of the MACHINA curriculum, presenting the methodology followed by the partnership to create a VET programme for relevant occupational groups in the ICT field. The programme will be offered as a market ready, customisable learning solution that can be directly used (entirely or components of it) by VET providers and employers for Machine Learning training provision,

This deliverable is the core for the achievement of the MACHINA objectives, marking the fulfillment of a key milestone and paving the way for the development of Open Educational Resources.

The document is structured as follows:

- Section 2 presents the methodological approach for the grouping of learning outcomes into learning units is presented. This includes: (i) the description of the methodology employed for designing learning units, (ii) an overview of grouping criteria and (iii) the presentation of the MACHINA learning units (incl. specifications).

- Section 3 provides an overview of the MACHINA curriculum, discussing curriculum details such as course objectives, target audience, recommended background and entry requirements, duration, and EQF level.
- Section 4 defines the specifications of individual learning units.

2 METHODOLOGICAL APPROACH

This section presents the methodological approach employed by the partnership for the design of curriculum structure, discussing the criteria used for grouping the defined learning outcomes (O1-T4) into modular learning units.

2.1 Methods to design learning units

While many countries have made significant progress in using learning outcomes to describe and present their qualifications to citizens, existing approaches differ in length and focus and make understanding and comparison difficult. Agreeing on a set of common principles for presenting qualifications, for example to be used in databases and in qualification supplements, would make it easier for learners, employees, and employers to understand the content and profile of a particular qualification. These common principles would not be to promote a harmonization of qualifications but should support end-users, be these individual citizens or employers, to make informed judgements and choices in diverse and complex education and training systems.

Units of learning outcome should be described in accordance with a common conceptual framework to allow a reciprocal understanding of the qualification and allow to an objective comparison between countries.

For the purposes of the project MACHINA and in accordance of CEDEFOP guidelines (www.cedefop.europa.eu), it is considered that a *unit of learning outcome* should be composed by the following components:

♦ **Title of the Qualification** to which the Unit relates

♦ **EQF Level**

The European Qualifications Framework (EQF) is a common European reference framework whose purpose is to make qualifications more readable and understandable across different countries and systems. Covering qualifications at all levels and in all sub-systems of education and training, the EQF provides a comprehensive overview over qualifications in the 39 European countries currently involved in its implementation. In close cooperation with the European Commission, Cedefop provides analytical and coordination support for the implementation of the EQF and carries out a number of comparative studies and analysis on issues related to the implementation of the framework at EU, national and sectoral level.

Source: https://www.cedefop.europa.eu/en/events-and-projects/projects/european-qualifications-framework-eqf)

♦ **Title of the Unit**

The title of the Unit should be as short as possible and should reflect the importance of the Learning Outcome(s) for the labour market. The title should reflect the global learning outcomes that are contained in the unit, and not focusing only on some of them.

♦ **Learning Outcomes**

Learning outcomes are statements that reflect/present the main technical tasks that the learner must perform to prove a specific output. Learning outcomes are expressed in a simple, short, and objective statement, beginning by the action verb that indicates the main technical task that the learner has to perform, conjugated in the infinitive. Learning outcomes are expressed in the form of knowledge, skills & competences statements.

Knowledge

Knowledge is the theoretical and/or factual body of facts, principles, theories, and practices that are related to a field of work or study. Knowledge is described in terms of what the learner knows and understands.

Skills

Skills are cognitive or practical abilities to apply knowledge and use know-how to complete tasks and solve problems. Skills are described in terms of what the learner can do.

Competence

A competence is considered the proven ability to use knowledge, skills and personal, social and/or methodological abilities at work or in academic situations and in professional and personal development. Competences are described in terms of what the learner does, applying knowledge, skills, and proving the following abilities: attitudes, personal, social and methodological.

♦ **Performance Criteria**

Performance criteria are the quality requirements associated with performance and the quality standards that ensure that the individual acts competently (required quality for achievements). The performance criteria are specifically associated with learning outcomes as expressed in the form of knowledge, skills, and competence. Performance criteria are measurable, observable and provide qualitative important information on the expected performance.

♦ **Outputs**

Outputs are the results, the obtained products, or the proof. The outputs are directly associated with learning outcomes and performance criteria, being the observable result of the performance. Outputs are

described in a clear, objective and short manner, expressing the main nuclear professional proof for a given qualification.

♦ Code (if applicable)

The title of the Unit should contain the national code used in the national qualifications' framework (when applicable). In cases where the work of reformulating the qualification for learning outcomes implied reformulating the description of the existing unit for a focus on the results of the learning process, rather than the existing description focused on the inputs and learning process, without any alteration in terms of the expected results of the learning process that would be achieved by a learner with a successful evaluation, the code existing in the national system is maintained. In cases where the reformulation of the qualification also entailed, for example, the dismantling of modules into several units of learning outcome, the code is assigned as follows: assignment of the national code in which these learning outcomes were contained, followed by an asterisk and an integer (1, 2, 3, …), assigned in ascending order of the number of units of learning outcome in which the original module was disassembled.

♦ Number of Hours

Although the number of hours of the Unit of Learning Outcome is of no relevance to the *matching process*, the number of hours is an indicator that helps to balance the size of the Unit between countries, and it is a fundamental indicator for the assignment of ECVET Points.

♦ ECVET Credit Points

In order to have a comprehensive view of the overall weight of learning outcomes in a qualification and the relative weight of Units in relation to the qualification, each Unit should contain the indication of the number of ECVET Points allocated to the Unit of Learning Outcome. The allocation of ECVET Points to Units of Learning Outcome is crucial for the validation and recognition processes of Units when the Learning Outcomes are acquired abroad.

Principles to be applied

The following principles should be used to agree on common learning outcomes:

1. It should be agreed among sending and receiving organizations that learning outcomes will consist of knowledge, skills and competence;
2. Both sending and receiving organizations should not replace existing learning outcomes descriptions as used at national or institutional level for qualifications, curricula or other purposes;
3. Sending partner should decide what learning outcomes their learners must achieve during the period abroad;

- It is very important to agree on a predefined structure and syntax. In the Project *MACHINA* it was decided to use the following structure to define learning outcomes:
- to describe knowledge, use the phrase "the learner knows and understands …"
- to describe skills, use the phrase "the learner is able to …"
- to describe competences, use the phrase "the learner does …"

It must be supported by a standardized terminology, including lists of action verbs.

In the Project *MACHINA* it was decided to use the structure presented in *Image 1* to define Units of Learning Outcome. The MACHINA project uses the learning outcome approach to design the curriculum and to connect the developed VET program with the European reference tools (EQF, ECVET). As the course delivery is different in various countries, this method potentially contributes to the alignment of the common content related to the blockchain technology education and required skills of the course learners. As shown in Figure 1, the method for designing learning units consists of 3 steps: (1) group learning outcomes; (2) test learning units; and (3) update learning units.

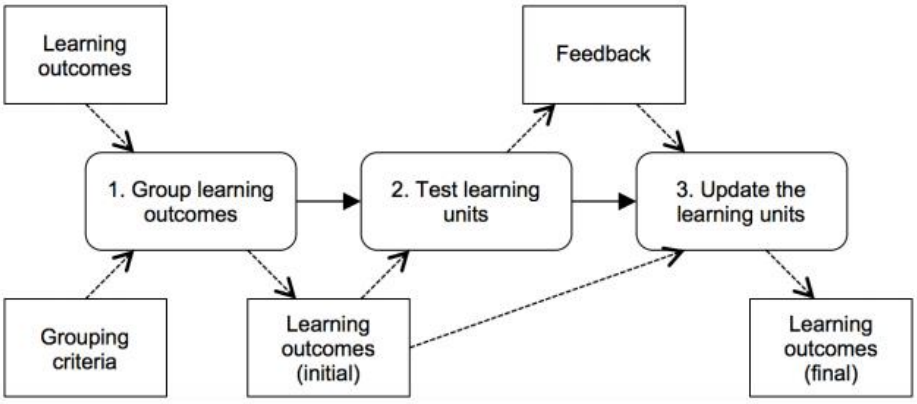

Figure 1: Method for Designing Learning Units Grouping learning units.

The input to the first step is (i) the evidence-based learning outcomes, specified in Deliverable O1-T1 and (ii) the grouping criteria, discussed on Section 2.2. This step involves the elaboration of the defined learning outcomes into 6 learning units as illustrated in Table 2.

LEARNING UNIT	TITLE	NUMBER OF LESSONS	Duration (teaching and sudying hours)	EQF level
1	Machine Learning essentials for ICT professionals	4	83h	5
2	Mathematics foundations	5	80h	5
3	Machine Learning algorithms, Programs and Protocols	6	100h	5
4	Deep Learning (Advanced)	4	80h	5
5	Communicating the merits, challenges, and implications of Machine Learning technology to customers and within own organization	5	83h	5
6	Legislation, Ethics, Project Management related to Machine Learning	4	83h	5

Table 2

Learning units will be further broken down into lessons to cover the entire spectrum of theoretical knowledge and (practical) skills and competences required to work with ML methods and applications. A lesson should include the following items: a title, the learning unit of which the lesson is part of, the list of topics of the learning unit content, prerequisites, learning materials, planned duration of the lesson and references. Training materials will be created and if suitable reused to support learning on the technical components and practical applications, such as lecture notes, slide presentations, case studies, FAQs.

The assessment of learning outcomes means methods and processes used to establish the extent to which a learner has in fact attained knowledge, skills and competences. In order to determine whether the learner has acquired the proposed knowledge, skills and competences and to provide learners with the opportunity to evaluate the extent to which they have attained the desirable knowledge and skills, assessment materials for each learning unit has been developed.

2.2 Grouping criteria

The learning outcomes was grouped following criteria of generality, graduality and interdependence. The grouping criteria followed consolidated educational approach based on topics' connection and concepts' structuring. Each learning unit has been divided into a set of coherent but, as much as possible, independent lessons to be used or composed freely. At this purpose we didn't avoid topics' overlapping. The main purpose of this framework is to provide support in grouping common Learning Outcomes into Nuclear Units as a step in the process of the transfer, recognition and certification of learning outcomes acquired by I-VET learners during their participation in European mobility programs.

In the context of the project MACHINA, Units of Learning Outcome are understood as a coherent set of knowledge, skills and competence needed to put into practice key realizations or key tasks, which are interconnected in a coherent, comprehensible, and logical set of key technical outcome, observable and verifiable in outputs.

The main rule for grouping *learning outcomes* into *units* is the coherence, interconnectivity, reciprocity and interdependence of knowledge, skills and competence associated with each *key technical outcome* among each other. The following criteria are considered to group *learning outcomes*: relation of *learning outcomes* to the same set of key technical tasks; relation of *learning outcomes* to the same product/outcome; relation of *learning outcomes* to the same production technique.

Each *unit of learning outcome* is composed of one or more *key technical outcome* which are interconnected and led to observable and evaluable *outputs*.

Whenever possible, *units of learning outcome* should be designed in such a way that can be achieved as independently as possible of other *units*, so that *learning outcomes* in a qualification should be assessed only once.

3 CURRICULUM OUTLINE

The curriculum has been composed in a way to cover horizontally the various aspects (scientific, technical, ethical, communicative) and topics of the machine learning field. This is coherent with course objectives; to give basic operative skills and general knowledge of machine learning theory and practice to workers not academically trained in the field. Consider the fact that if today basic information technology knowledge and skills for workers in the service industry are basically the use of the "office packet" (emailing, text processing, calculus sheets) in the feature knowledge and basic use of ML algorithms will be probably necessary. The curriculum has been designed for a general audience, so that independently from the individual technical or scientifical entry level, everyone could choose learning units accordingly to personal or company interests or educational needs. The entry level is post-graduation in any course with basic mathematical courses. The duration of the course will last 3-4 months, considering 2 hours per day of learning activities. The targeting EQF level is 5-6.

4 LEARNING UNIT SPECIFICATIONS

Learning Unit 1: ML essentials for ICT professionals				
Unit description	Defines the essential ML characteristics and addresses the fundamental features of ML applications.			
Learning objectives	- Get an overview of the ML characteristic and its different algorithms. - Understand the concept behind ML and how to detect patterns from data. - Identify different types of applications that use the ML algorithms.			
Lessons	1. Introduction to ML. 2. Where to apply ML. 3. Machine learning and Data processing. 4. Example ML applications.			
Learning outcomes	Lesson 1 - Understand the theoretical principles of Machine Learning - Get a general overview of the different machine learning algorithms.	Lesson 2 - Types of problems that Machine Learning algorithms can solve nowadays (ex. regression and classification) - How to solve the problems using various Machine Learning techniques.	Lesson 3 - Understand Data preprocessing and visualization methods.	Lesson 4 - Understand the elements of ML in applications. - Analyze some existing ML applications according to a given context.
EQF level	5			
ECVET credits	5			
Duration	83 hours			
Recommended background	Basic understanding of Linear Algebra, Background on computer science.			
Prerequisites	Basic knowledge of Python language			
Learning materials	• 21 pages with lecture notes • 4 presentation files with 66 slides in total • 10 Questions and Answers • 2 Case Studies			
Assessment materials	• 2 practical exercises on Juoyter IPython NoteBook with indicative solutions • 10 multiple choice questions			

Learning Unit 2: Mathematical Foundations					
Unit description	Defines the mathematical foundation required for writing programs and algorithms for ML and AI.				
Learning objectives	To break down the difficult mathematical concepts into easier one to understand concepts. To focus on mathematical concepts and algorithms to get full understanding of ML and AI techniques and methodologies.				
Lessons	1. Set, Functions, Relations 2. Linear Algebra 3. Probability Theory 4. Statistics 5. Computation theory				
Learning outcomes	Lesson 1 -To know the definition of sets and basic sets' operations -To know definition of function and basic functions' operations -To know definition of relation, equivalence relation, partition of a set -To know the concept of local minima and derivatives of a function	Lesson 2 -To know the definition of vector space and basic vector operations -To know the definition of metric -To know the difference between scalar, vector, tensor -To know how calculate the Hadamard product -To know the definition of the gradient of a function	Lesson 3 -To know the frequentist definition of probability of an event -To know the definition of probability as ratio between favorable outcomes on total outcomes -To be able to calculate easy probabilities base on basic combinatorics -To know the definition of join probability	Lesson 4 -To know the definition of population and sample -To know the meaning and to be able to compute mean, median, variance, standard deviation of a population -To know the meaning of covariance and correlation -To know the meaning of maximum likelihood estimator	Lesson 5 -To know the concept of algorithm -To be able to write a simple algorithm as a flow chart -To know the basics of procedural programming language (operations, conditions, if-else, while, for) -To be able write a simple algorithm in a programming language (Python) -To know the basic data

Learning Unit 2: Mathematical Foundations					
	-To be able to compute an approximation of derivative at a point using deltas		-To know the definition of independent events -to know the definition of conditional probability -To know the Bayes Theorem	-To know the meaning of univariate and multi variate linear regression and how to compute the parameters -To know the definition of correlation matrix -To know the meaning of logistic regression -To know the definition of precision, recall, confusion matrix	structures (sets, lists, associative, arrays) -To know the concept of classes, instances, methods
EQF level	5				
ECVET credits	4.8				
Duration	80 hours				
Recommended background	None				
Prerequisites (in terms of software)	Knowledge of a programming language				
Learning materials	• 26 pages with lecture notes • 1 presentation file with 15-20 slides • 15 Questions and Answers • 2 Case Studies				
Assessment materials	• 2 practical exercises • 15 multiple choice questions				

Learning Unit 3: ML Algorithms, Programs and Protocols						
Unit description	Defines the foundational machine learning models and understands how to select the suitable ML model for a given problem and how to implement it in one of the available programming languages.					
Learning objectives	- Foundational understanding of machine learning models. - Understand some of the essential machine learning algorithms and how to evaluate the performance of them. - Identify different programming languages and frameworks that support the implementation of machine learning algorithms.					
Lessons	1. Machine learning by linear models 2. Supervised learning 3. Unsupervised learning 4. Semi supervised learning 5. Programming languages and frameworks for Machine learning algorithms 6. Best practices for ML					
Learning outcomes	Lesson 1 - Get an overview of ML linear models. - Identify the different ML linear models' algorithms and implementation.	Lesson 2 - Get an overview of supervised learning and its utility. - Identify the different algorithms of supervised learning and implementation.	Lesson 3 - Get an overview of unsupervised learning and its utility. - Identify the different algorithms of unsupervised learning and implementation.	Lesson 4 - Get an overview of semi-supervised learning and its utility. - Identify the different algorithms of semi-supervised learning, and implementation.	Lesson 5 - Obtain an overview of the different programming languages and frameworks available for ML.	Lesson 6 - Understand best practices for building machine learning applications. - Identify Hyperparameter Tuning methods.
EQF level	5					
ECVET credits	6					
Duration	100 hours					
Recommended background	Basic understanding of Linear Algebra, and probability theory. Learning Unit 1 and 2					

Learning Unit 3: ML Algorithms, Programs and Protocols	
Prerequisites (in terms of software)	Basic knowledge of Python language
Learning materials	• 18 pages with lecture notes • 6 presentation files with 112 slides in total • 15 Questions and Answers • 2 Case Studies
Assessment materials	• 3 practical exercises on Juoyter IPython NoteBook with indicative solutions • 15 multiple choice questions

Learning Unit 4: Deep Learning (Advanced)				
Unit description	The content of this unit is a general introduction to basic concepts relating with the most common neural networks models used in real life, i.e.: Multilayer Perceptron, Convolutional Networks, Recurrent Networks, Restricted Boltzmann Machines			
Learning objectives	To understand the important details about deep neural networks and get to know of different deep neural network architecture. To identify the potential of deep learning in different applications such as natural language processing, computer vision, or recommendation systems.			
Lessons	1. Multilayer Perceptron (MLP) 2. Convolutional Neural Networks (CNN) 3. Recurrent Neural Networks (RNN) 4. Autoencoders (AE), Restricted Boltzmann Machines (RBM)			
Learning outcomes	Lesson 1 -To know the definition of MLP -To know when to use MLP model -To know definition of different activation functions -To know basic cost functions' definition -To know common gradient descent techniques to minimize cost functions -To know general principles of back propagation algorithm -To know how to tune model fitting -To be able to implement, train, tuning and validate a MLP model using Keras API	Lesson 2 -To know basic CNN filters -To know when to use CNN model -To know basic CNN architectures -To know basic concepts about transfer learning, end-to-end learning, multi-task learning -To be able to implement, train, tuning and validate a CNN model using Keras API -To be able to import a pre-trained CNN to solve specific problem	Lesson 3 -To know the definition of RNN -To know what a sequence model is -To know when to use RNN model -To know basic RNN architectures and modules (GRU, LSTM) -To be able to implement, train, tuning and validate a RNN model using Keras API	Lesson 4 -To know the definition of AE -To know the definition of RBM -To be able to implement, train, tuning and validate a AE model using Keras API -To be able to implement, train, tuning and validate a RBM model using Keras API

Learning Unit 4: Deep Learning (Advanced)	
EQF level	5
ECVET credits	4.8
Duration	80 hours
Recommended background	Learning unit 1,2,3
Prerequisites (in terms of software)	Knowledge of the basics of Python programming language
Learning materials	• 23 pages with lecture notes • 4 presentation files with 66 slides in total • 18 Questions and Answers • 2 Case Studies
Assessment materials	• 2 practical exercises • 18 multiple choice questions

<table>
<tr><th colspan="5">Learning Unit 5: Communication</th></tr>
<tr><td>Unit description</td><td colspan="4">Through this course, each participant builds on their communication strengths and learn new and interesting techniques to add to their skillset.
This course will empower the participant to become an advanced communicator at workplace.
Each participant will learn the elements of communication and be able to flex each one to meet objectives.
The information and practice gained through this course will help bridge the gap in participants current verbal skills.</td></tr>
<tr><td>Learning objectives</td><td colspan="4">• Get familiar with basic communication principles and practices.
• Understand the components of effective communication and ways for using Machine Learning in Communications.
• Identify different types of application of ML in communication environments (eg. at the workplace).</td></tr>
<tr><td>Lessons</td><td colspan="4">1. Introduction to communication and ML involvement
2. Types, levels, components of effective communication and ways for using Machine Learning in Communications
3. The future of communication in accordance with artificial intelligence
4. The effects of artificial intelligence in communication</td></tr>
<tr><td>Learning outcomes</td><td>Lesson 1
- Describe fundamental communication principles and practices
- Select creative and appropriate modalities and technologies to accomplish communicative goals
- To know the importance of communication in the 21st Century
- To know the different methods of effective business</td><td>Lesson 2
- Differentiate between various approaches of communicating issues
- To know the components of communication
- Present messages in multiple communication
- To understand how machine learning and artificial intelligence can help organizations and communications</td><td>Lesson 3
- To understand the positive communication
- To understand the role of AI and Machine Learning in communication
- To explain the relation between new media and communication</td><td>Lesson 4
- Identify contexts, situations and barriers that impede communication self-efficacy
- Adapt messages to the diverse needs of individuals, groups and contexts
- Differentiate between various approaches of communicating issues</td></tr>
</table>

Learning Unit 5: Communication				
	communication in brief - To know about the ML involvement in communication and organizations			
EQF level	5			
ECVET credits	5			
Duration	83 hours			
Recommended background	Learning Unit 1, 2, 3, 4			
Prerequisites (in terms of software)	Online conference tools (Zoom, Teams, Google Meets etc.)			
Learning materials	• 20 pages with lecture notes • 4 presentation files with 47 in total • 9 Questions and Answers • 2 Case Studies			
Assessment materials	• 2 practical exercises • 15 multiple choice questions			

Learning Unit 6: Legislation, Ethics, Project Management related to ML				
Unit description	Introduced the EU ethical and legal regulations for ML applications. Identify the life cycle, and project management requirement for an AI application.			
Learning objectives	- Understand the EU law and regulations for AI and ML applications. - Identify the different type of bias in AI and their consequences. - Know the project management requirement and lifecycle for AI applications.			
Lessons	1. EU guidelines on ethics in artificial intelligence. 2. Bias in Machine learning. 3. Software engineering for AI applications. 4. Project Management			
Learning outcomes	Lesson 1 - Get an overview of the EU ethics for AI and ML applications. - Identify the AI Regulation for AI applications.	Lesson 2 - Get a look about the bias in ML. - Identify the different types of machine learning bias.	Lesson 3 - Understand the project Lifecycle for an AI application. - Get an overview of the software architecture used for an AI application.	Lesson 4 - Get an overview of project management. - Define a data collection project.
EQF level	5			
ECVET credits	5			
Duration	83 hours			
Recommended background	Learning Unit 1			
Prerequisites (in terms of software)	n/a			
Learning materials	• 14 pages • 60 slides • 9 Questions and Answers • 2 Case Studies			
Assessment materials	• 2 practical exercises • 11 multiple choice questions			