ARIS PROJECT

AI SKILLS FOR ICT PROFESSIONALS

(O1-T4c)

Definition of ARIS learning outcomes

BT

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Acronyms and abbreviations

AI	Artificial Intelligence
ARIS	Artificial Intelligence Skills For ICT Professionals
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.	Masters of Science
MOOC	Massive Open Online Course
ML	Machine Learning
NN	Neural Network
OER	Open Educational Resources
VET	Vocational Education and Training

1 Introduction

The growing penetration of AI technology across the major sectors of the EU economy is increasing the need of up-skilling ICT professionals so that they are able to understand and work on AI applications.

The purpose of the ARIS project is to address this challenge by delivering a modular curriculum and Open Educational Resources (OERs) on AI technology and practical applications, enhancing the relevance of VET provision for ICT professionals to suit their skills with cutting-edge ICT innovations and enhancing employment.

The first intellectual output of the ARIS project includes tasks which help to define the specifications (i.e. learning outcomes) for the ARIS course curriculum. Accordingly, we have carried out a field research and a desk research which the results were published in the following documents:

- **ARIS_O1-T4_a1_ Analysis of evidence (field research)_2020_01_12.docx**[1]
- **ARIS_O1-T4_a2_ Analysis of evidence (desk research)_2020_02_13.docx**[2]

The first document provides the analysis of the results of the online questionnaires (field research), while the second document provides the analysis of the results of the skill matching between AI skill demand and AI skill supply (desk research).

This report provides the initial definition of ARIS learning outcomes. It is based on the results of the abovementioned Deliverables. It represents the outcome of the O1-T4_b deliverable, namely "ARIS Learning Outcome Report" (O1-T4-a2). The report is structured as follows:

- **Section 2** summarizes the most important findings of each analysis presented in the two abovementioned deliverables.

[1] https://freedcamp.com/ARIS_partnership_COV/ARIS__Artificial_J91/files/versions/8017345
[2] https://freedcamp.com/ARIS_partnership_COV/ARIS__Artificial_J91/files/versions/8289990

- **Section 3** provides the definitions of the learning outcomes of the project ARIS VET program on AI technology in the form of statements of what ICT professionals should know, understand and be able to do upon the completion of the ARIS course. The definitions of the learning outcomes rely on the European reference frameworks and standards (EQF and ECVET) to develop the learning outcomes in terms of definitions of knowledge, skills and competences..
- **Section 4** presents guidelines on how to prepare learning units corresponding to the ARIS learning outcomes.

2 Synthesis of findings regarding the field research and the desk research

In this section, we bring out the main findings from the field research the (online questionnaire), which is detailed in the report entitled *ARIS_O1-T4_a1_* Analysis *of evidence (field research)_2020_01_12*, as well from the desk research (current required skills and current provided AI training), which is detailed in the report entitled *ARIS_O1-T4_a2_ Analysis of evidence (desk research)_2020_02_13*.

According to the questionnaire respondents, the five most needed field knowledge for working on AI applications and related services (Figure 1) are, in decreasing order:

- *Machine Learning Algorithms* (18.91 %),
- *Programming Languages for AI* (18 %),
- *Data mining Concepts and Techniques* (15.73 %),
- *Probability and Statistics* (15.58 %),
- *Ethical, legal and social implications of Artificial Intelligence* (10 %).

No far behind we find *Foundations of Cognitive Science* (9.08 %), *Project Management Principles* (5.90 %), and *Elements of Social Cognition* (3.78 %). Finally, with the least number of answers, we find *AI applications in Banking, Finance and Public Services* (3.33 %).

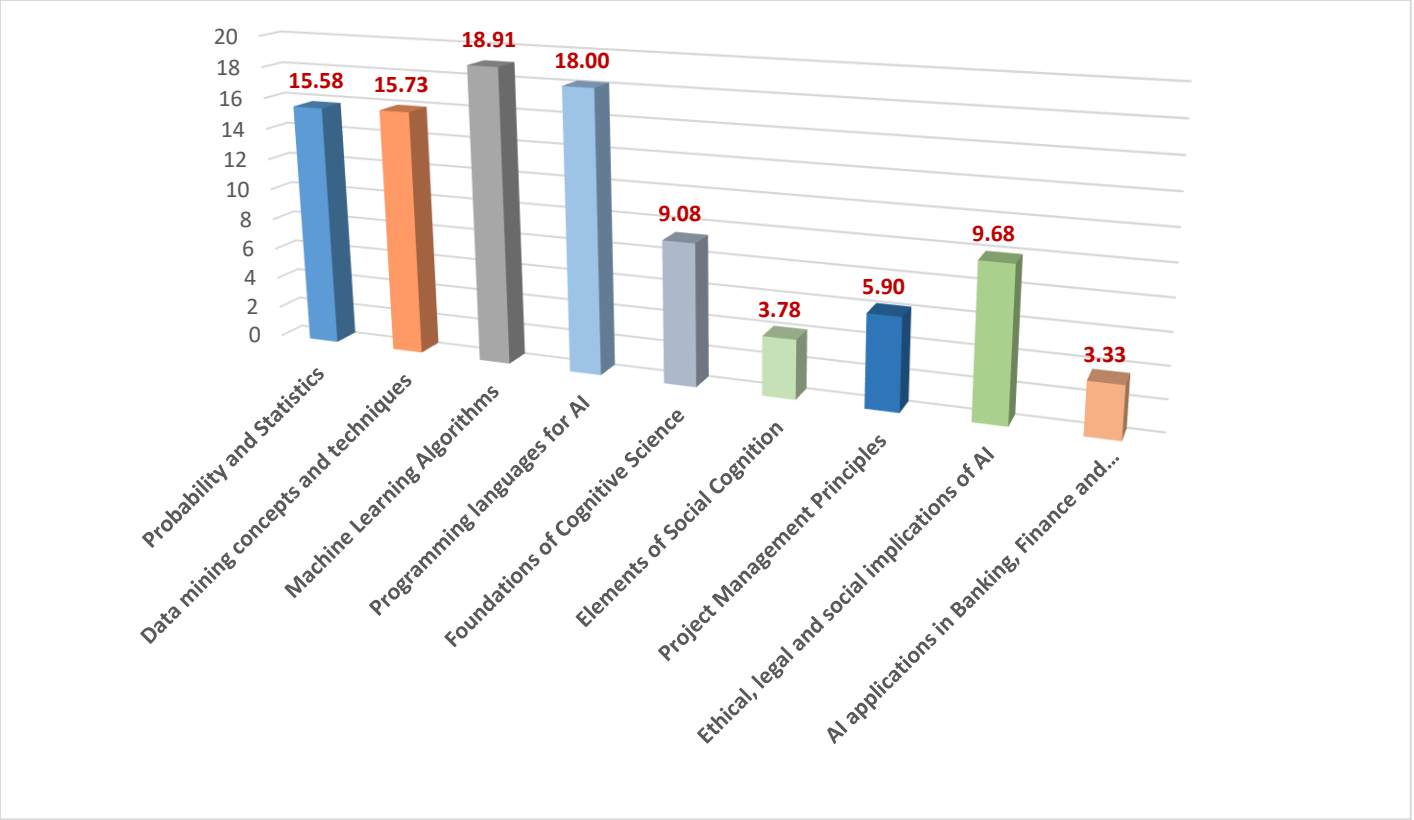

Figure 1. Most needed field knowledge for working on AI applications and related services (%).

Regarding the four most important skills to work as AI professional, the respondents valued the most (**Error! Reference source not found.**), in decreasing order:

- *Apply concepts of machine learning in real life problems (17.47 %)*
- *Develop machine learning models (15.61 %)*
- *Identify patterns in data (11.41 %)*
- *Create artificial neural networks (10.36 %)*

With less than 10% of the answers we find Develop proof of concepts for envisioned AI applications (9.89 %), Develop tailor made AI solutions for businesses (9.27 %), Assess implications and possibilities of AI application in a business context (8.50 %), Communicate the merits of AI technologies to potential customers (6.49 %) and Lead organisational changes to support the integration of AI in a business context (5.56 %). Finally, with the least number of answers, we find Communicate insights from data to business stakeholders (5.41 %).

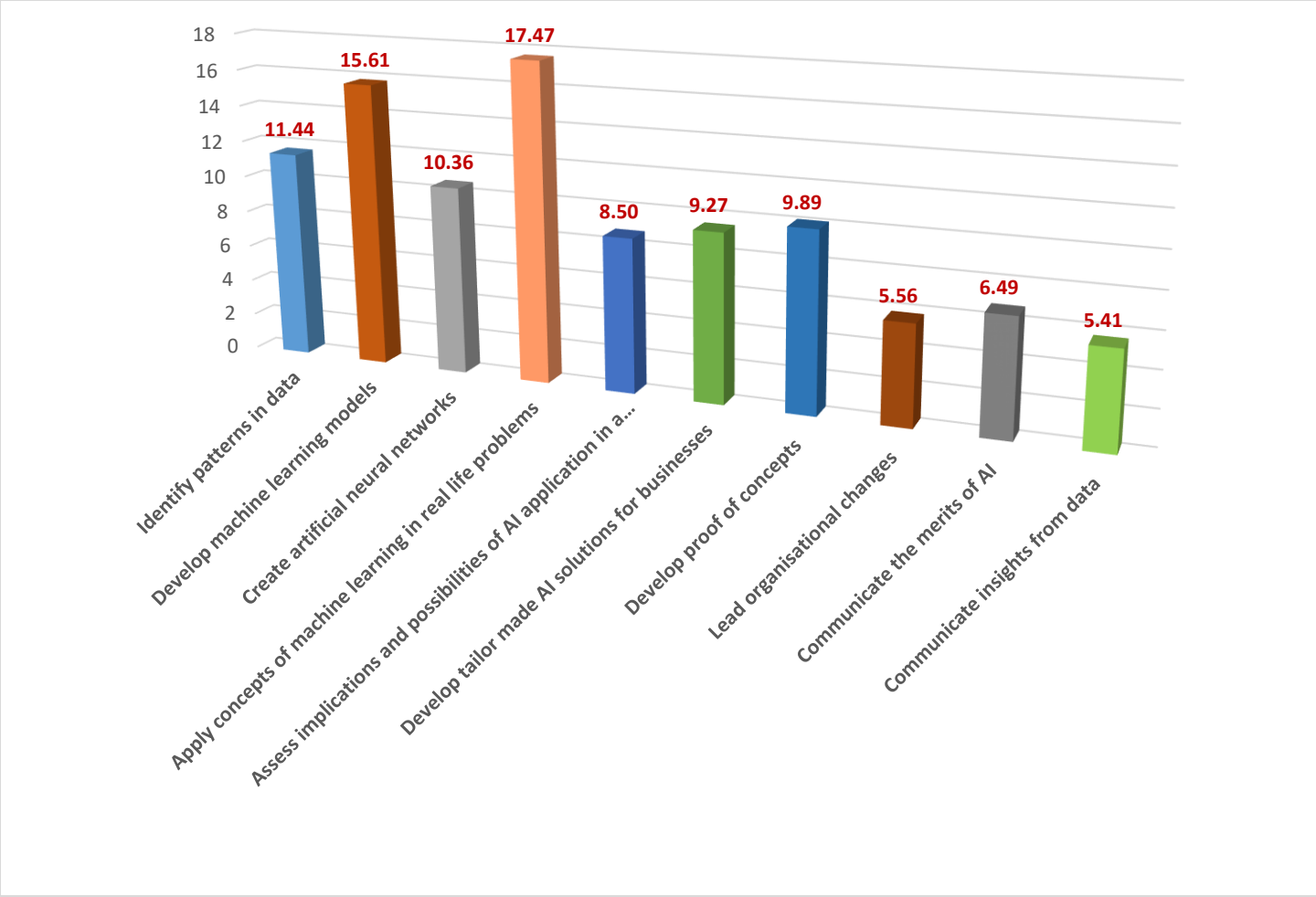

Figure 2. Most important skills to work as AI professional.

As we highlighted in the report *ARIS_O1-T4_a2_ Analysis of evidence (desk research)_2020_02_13*, most AI curricula are available at academia. These curricula are offered at specialized master's degrees, usually restricted in access, resulting in a few educated individuals.

On the other hand, the most existing AI training programs are paid, so it is expensive to follow entire learning paths. In addition, the offer in terms of training dealing with AI and related subjects is not that varied.

The desktop research has also shown that tech firms in EU that are focusing on AI are struggling to find suitable candidates from the current workforce. Further to demand, the gap is amplified by the shortage and inadequacy of relevant skills expected via VET provision.

The upgrading of initial and continuous VET provision in the field is therefore essential so that existing and future ICT professionals can acquire and develop the AI skills

and competences required to respond to modern workplace requirements and succeed in a competitive employment market.

3 Definition of learning outcomes

Aligned with the provisions of the project Application Form and the O1-T1 deliverable, the definition of the ARIS learning outcomes is based on the European Qualification Framework (EQF) [1], as the latter acts as a translation device to make national qualifications more readable and comparable across Europe, aiming to promote workers' and learners' mobility between countries and facilitate their lifelong learning. The EQF relates different countries' national qualifications systems and frameworks together around a common European reference – its eight reference levels based on **"learning outcomes"** (defined in terms of knowledge, skills and competences). Learning outcomes do not describe the learning target or the learning path, but the result following the completion of a learning process.

According to the 2017 CEDEFOP handbook *Defining, writing and applying learning outcomes* [2], learning outcomes are "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 competences". We recall their definition, as mentioned in the O1-T1 deliverable:

- **Knowledge**: The outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories and practices related to a field of work or study. According to the EQF, knowledge is described as theoretical and/or factual.
- **Skill**: The ability to apply knowledge and use know-how to complete tasks and solve problems. According to the EQF, skills are described as cognitive (involving the use of logical, intuitive and creative thinking) and practical skills (involving manual dexterity and the use of methods, material tools and instruments).
- **Competence:** The proven ability to use knowledge, skills and attitudes, in work in study situations and in professional and personal development. According to the EQF, competence is described in terms of responsibility and autonomy.

While learning outcomes promote overall transparency and help to clarify the intentions of learning processes, the CEDEFOP handbook [2] also points out some criticism to the learning outcomes approach. Among other imperfections, "it can be argued that learning outcomes can inhibit the learning process, for example when indicating (too) restricted a threshold level. Too much specificity and detail, it is argued, also makes it difficult to give room for innovation and exploit the unexpected present in any situation" ([2], page 39). Indeed, the learning outcomes approach is seen, by some constructivist schools of thought, as 'policy hype' and as a threat to high quality education, training and innovation. To try to improve these flaws, ([2] page 40) stress the importance of aligning learning outcomes statements to teaching and learning practices as well as to assessment tasks. Aligning learning outcomes to teaching and learning is about connecting the abstract idea of a learning outcome to what teachers actually do to help students learn, and the things that students do to learn.

In fact, learning-outcomes-based approaches have different origins and have been promoted by different schools of thought. While the behaviouristic tradition emphasises learning outcomes as result-oriented, full-ended, clearly observable and (objectively) measurable, the constructivist approach will emphasise the need for learning outcomes to be process-oriented and open-ended, limiting quantified measurability.

The CEDEFOP handbook [2] also emphasises *the writing and articulation of learning outcomes must be followed by implementation, through teaching, learning and assessment*. Learning outcomes statements form an important part of curricula. They guide teachers in the teaching process, for example supporting the choice of methods, and they inform learners about what they are expected to know/do and understand after a given learning activity.

The definitions and descriptions of learning outcomes as used in curricula are statements and expressions of intentions. They are not outcomes of learning, but desired targets. Achieved learning outcomes can only be identified following the learning process, through assessments and demonstration of achieved learning in real life, for example as the result of following the training.

The European e-Competence Framework (e-CF) [3] - version 3.0 claims to be the first sector-specific implementation of the EQF, arguing to provide a reference of 40 competences as required and applied at the Information and Communication Technology (ICT) workplace, using a common language for competences, skills and capability levels that can be understood across Europe. The e-CF is used as guidance in the formulation of the ARIS learning outcomes as presented in the next section.

3.1 Formulation of the ARIS learning outcomes

It is worth to emphasise, in line with the provisions of the project Application Form and the O1-T1 deliverable, the project ARIS aims to strengthen the key competences of ICT professionals (namely initiative, entrepreneurship and communication skills), rather than focus on the technical and coding skills associated with AI technology, which risk being outdated by the time the project will make available its results to its target groups. To this end, the content of AI curricula is based on the training needs analysis and organised in learning units as follows:

- **Learning unit 1**: Foundations of Artificial Intelligence
- **Learning unit 2**: Machine Learning
- **Learning unit 3**: Neural Networks and Deep Learning,
- **Learning unit 4**: AI for solving real-life problems.

The learning outcomes of each learning unit are specified hereafter, in Table 1 to 4, in terms of knowledge, skills and competences. These correspond to statements of what ICT professionals should know, understand and be able to do upon the completion of the ARIS course.

Table 1: ARIS Learning unit 1 learning outcomes

<table>
<tr><th>Learning unit 1</th><th colspan="3">Foundations of Artificial Intelligence</th></tr>
<tr><td rowspan="3">Learning outcomes correspond to EQF Level 4</td><td colspan="3">Defines the essential AI characteristics. Addresses the fundamental features of AI applications.</td></tr>
<tr><td>Knowledge</td><td>Skills</td><td>Competence</td></tr>
<tr><td>Knows / Aware of:
- Definitions of Artificial Intelligence</td><td>Able to:
- Explain the scope of AI differentiating</td><td>Able to:
- Give an account of the main methods used in</td></tr>
</table>

	- Main topics and areas of Artificial Intelligence - Methods for problem solving using search algorithms - Methods for knowledge representation using logic and probabilistic formalisms - Methods for Machine Learning - Natural Language Processing - Ethical implications of AI	applications from methods and techniques - Identify a potential application of AI and critically chose the AI sub-field that may be applied - Provide examples of problems that must be addressed with deterministic or probabilistic AI methods - Differentiate the knowledge representation, learning and reasoning components in a given AI system. - Explain the ethical implications of an AI deployment and anticipate the ethical dilemmas that may have to be addressed.	AI solutions and the main areas where AI has been successful - Autonomously explain the benefits and risks of AI solutions in terms of performance, accuracy - Examine a suitable real-world problem and abstract its elements to suit one of the AI paradigms

Table 2: ARIS Learning unit 2 learning outcomes

Learning unit 2	**Machine Learning**		
Learning outcomes correspond to EQF Level 4	Defines the foundations for Machine Learning. Teaches how to select the right ML model and to implement it in a given domain.		
	Knowledge	**Skills**	**Competence**
	Knows / Aware of: - Typology of Machine learning problems	Able to:	Capable to: - Evaluate the feasibility of

	(supervised vs unsupervised, classification vs regression) - Theoretical principles of Machine Learning - Data transformation and visualization - Principles and methods of linear ML for classification and regression problems - Principles and methods of nonlinear ML for classification and regression problems - Principles and methods of unsupervised ML - Evaluation of Machine Learning models - Languages and resources for ML -	- Provide examples of the different ML types of problems - Identify the ML component in a software system - Communicate the potential of ML methods critically telling advantages and disadvantages with respect more traditional approaches - Formalize requirements of a ML solution, collect the set of methods that may be applied and critically design a plan to test and evaluate the different alternatives - Identify languages and other resources for specific ML applications.	implementing a suitable ML algorithm in a novel domain - Provide expertise on a detailed plan to gather the right data, develop the right algorithm taking advantage of existing resources and conducting a suitable validation. - Examine a given problem, identify the component that may be formalize as a ML task and recognize the appropriate typology that is more suitable - Critically identify the strengths and weaknesses of a ML solution vs a hard-wired solution, the potential benefits and challenges in different types of scenarios - For a given problem, formalize requirements of a ML solution, collect the set of methods that may be applied and critically design a plan to test and evaluate the different alternatives - Recognize the relevant data by choosing the right visualizations and

			the right transformation from raw noisy data. - Design a plan for testing a ML solution, evaluate its performance and validate its accuracy.

Table 3: ARIS Learning unit 3 learning outcomes

Learning unit 3	**Neural Networks and Deep Learning**		
Learning outcomes correspond to EQF Level 4	Defines the foundations for Neural Network (NN) and Deep Learning (DL). Teaches how to implement solutions using NN and DL algorithms in a given domain.		
	Knowledge	**Skills**	**Competence**
	Knows / Aware of: - Principles of neural networks - Perceptrons and Multi-Layer Perceptrons - Convolutional Neural Networks - Recurrent Neural Networks - Optimization algorithms for learning in neural networks - Deep learning architectures for image processing - Deep learning architectures for natural language processing	Able to: - Understand the neural metaphor of NNs and differentiate it from the mathematical abstraction. - Explain and communicate different types of NN and identify typical domains where each type is more suitable - Recognize the analogy between learning in the neural metaphor and optimizing a cost function in the mathematical abstraction. - Provide examples of the different types of problems that can be	Able to: - Evaluate the feasibility of implementing a suitable NN architecture and DN algorithm in a novel domain - Provide expertise on a detailed plan to gather the right data, develop the right algorithm taking advantage of existing resources and conducting a suitable validation.

	- Languages and resources for NN and DL.	addressed with NN explaining potential benefits and challenges. - Identify the NN or DN component in a software system - Examine a given problem and identify the appropriate typology of NN that is more suitable for it. - For a given problem, formalize requirements of a NN or DN solution, collect the set of methods that may be applied and critically design a plan to test and evaluate the different alternatives - Identify languages and other resources for specific NN and DN applications - Design a plan for testing a NN or DN solution, evaluate its performance and validate its accuracy.	

Table 4: ARIS Learning unit 4 learning outcomes

Learning unit 4	**AI for solving real-life problems**		
Learning outcomes correspond	Provides the expertise of the hole software development cycle of an AI solution.		
	Knowledge	**Skills**	**Competence**

to EQF Level 4	Knows / Aware of: - Application of AI for object classification in images - Application of AI for image segmentation - Application of AI for gesture recognition - Application of AI for classification in natural language processing	Able to: - provide detailed examples of successful AI industrial applications - explain and communicate the design and development of use cases and proofs of concept at their different phases to potential users and stakeholders - explain, communicate and anticipate advantages and disadvantages of AI vs non-AI solutions - Critically select existing languages and resources for scenarios where AI has already been proved successful.	Able to: - Analyse strengths, weakness, opportunities and threats of AI solutions for specific industry, mainly on those domains where the technology has already been tested and resources can be reused. - Provide expertise of the hole software development cycle of an AI solution including design, development and validation - Monitor the intervention of AI technology in business models

4 Guidelines on how to prepare corresponding lessons.

The ARIS learning outcomes lay the ground for the formulation of ARIS learning units. The learning units should be specified in intellectual output 2, according to the project application form. As so, this section intends to provide guidelines on how to prepare the ARIS lessons. Table presents a template and example of specification of a lesson and guidelines for learning materials. A lesson should include the following items: a title, the lesson of which the learning unit is part of, the list of topics of the lesson 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, and audio-visual aids.

Assessment of learning outcomes means methods and processes used to establish the extent to which a learner has in fact attained particular 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 lesson will be developed.

Table 5: Template and example of specification of a lesson

Lesson title: Learning models in Machine Learning
Part of learning unit 2 – Machine Learning
Lesson objectives
- Give a global overview of the different models in Machine Learning - Be able to select the right learning model and apply it for a given real-life situation
Topics / Content
This lesson is comprised of the following parts: - Part 1: Overview of Machine Learning models - Part 2: Supervised Learning - Part 3: Unsupervised Learning - Part 4: Reinforcement Learning - Part 5: Feature engineering - Part 5: Time series modelling - Part 7: ML Case study

Prerequisites
- Have followed learning unit 1 of the ARIS curricula, if no previous knowledge on the AI fundamentals - Knowledge of Python programming language
Learning materials
Presentation slides and lecture notes: 40-60 Exercises: 2-4 FAQs: 10-20 Case studies: 2-3 For this learning unit, situation case studies can be useful. The situation case requires an analysis of the information embodied in the case and asks students to delineate the significant relationships existing among the various items of information. The forum discussion is designed to develop an understanding of why things went wrong and how that could have been avoided. Assessment material: Multiple choice questions and quizzes, case studies and application scenarios analysis will comprise the bulk of assessment material. Multiple choice questions: 20-30 Short response questions: 5-10 case studies and application scenarios analysis: 1-2 All learning materials will be available in English and in the partnership languages (FR, NL, IT, ES, GR, LT).
Planned duration of the learning unit
- Average duration for reading the lecture notes and slide presentations: 4h - Learner personal work: 10h
References

1. Different Types of Learning in Machine Learning, A Tutorial for Beginners, Jason Brownlee, 2019, https://medium.com/crypto-currently/build-your-first-smart-contract-fc36a8ff50ca
2. Machine Learning: Supervised Learning vs Unsupervised Learning, Gowthamy Vaseekaran, 2018, https://medium.com/@gowthamy/machine-learning-supervised-learning-vs-unsupervised-learning-f1658e12a780

References

[1] The European Qualifications Framework, https://ec.europa.eu/ploteus/search/site?f%5B0%5D=im_field_entity_type%3A97 and http://www.cedefop.europa.eu/en/events-and-projects/projects/european-qualifications-framework-eqf

[2] CEDEFOP (2017). Defining, writing and applying learning outcomes - A European handbook, Luxembourg: Publications Office of the European Union, http://www.cedefop.europa.eu/en/publications-and-resources/publications/4156

[3] The European e-Competence Framework (e-CF) - A common European framework for ICT Professionals in all industry sectors, http://www.ecompetences.eu/