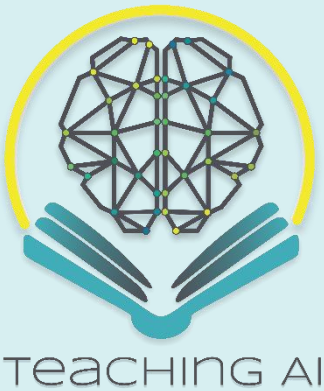

Report WP2-A3:

Finalised set of project ILOs

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Result

Report on the final project intended learning outcomes for TAI MOOCs

Related to

WP2-A3: Analysis of the desired ILOs and the definition of the set of ILOs we want to follow within the project

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Note

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1. Introduction

Work Package 2 – Activity 3 (WP2-A3) represents the final stage of defining the Intended Learning Outcomes (ILOs) for the Teaching Artificial Intelligence (TAI) project. Building on the consolidated set of desired ILOs developed in WP2-A2, this activity focuses on refining, validating and finalising the project-level ILO framework that will guide the development of the TAI Massive Open Online Courses (MOOCs) and associated educational materials. While WP2-A2 established a common educational foundation by harmonising partner contributions into a consolidated framework, WP2-A3 transforms this framework into a coherent and actionable set of project ILOs that will be consistently applied throughout the subsequent stages of the project.

The work presented in this report is founded on the outcomes of the two preceding activities within Work Package 2. WP2-A1 provided a comprehensive analysis of AI- and machine learning-related courses across the partner institutions, identifying both the existing strengths of current curricula and several important curricular gaps, particularly in advanced AI paradigms, deployment-oriented competencies, industrial applications, responsible AI, and the formulation quality of existing ILOs. Based on these findings, WP2-A2 developed a consolidated framework of desired ILOs by integrating partner contributions, harmonising their structure and establishing a common educational vision for AI teaching across the consortium. WP2-A3 builds upon this work by evaluating the consolidated framework, confirming its educational coherence and defining the final project ILOs that will serve as the reference point for all educational outputs of the TAI project.

In addition to defining the final project ILOs, this activity provides a comprehensive educational analysis of the resulting framework. The final ILOs are examined from multiple perspectives, including their distribution across Bloom's taxonomy, their relationship to the competence domains of knowledge, skills and competences, and their ability to address the curricular gaps identified in WP2-A1. This analysis ensures that the final project ILO framework is pedagogically balanced, educationally coherent and aligned with both contemporary developments in artificial intelligence and the broader objectives of European higher education.

The report also establishes a direct link between the final project ILO framework and the subsequent development of the TAI MOOCs within WP5. The defined ILOs provide the basis for structuring MOOC modules, selecting appropriate teaching methods, designing assessment strategies and ensuring constructive alignment between learning objectives, learning activities and assessment. By translating the final project ILOs into practical

recommendations for educational design, WP2-A3 ensures that the project's teaching materials are not only academically sound but also relevant to current industrial practice and future developments in AI education.

Following this introduction, the report presents the final project ILO framework together with its mapping to Bloom's taxonomy and competence domains. It then analyses how the final ILOs address the curricular gaps identified in WP2-A1 and discusses their implications for the design of TAI MOOCs, including recommendations for module structure, teaching methods and assessment strategies. The report concludes by summarising the contribution of the final project ILO framework to the overall educational objectives of the TAI project.

The University of Ljubljana (UNILJ) is the leading organisation and coordinator for this work package.

2. Final project ILO framework

This section presents the final project Intended Learning Outcomes (ILOs) adopted within the TAI project. Building upon the consolidated framework developed in WP2-A2, the final ILO set represents the educational reference framework that will guide the design, development and evaluation of the TAI MOOCs and associated teaching materials.

The final project ILO framework preserves the common educational vision established in WP2-A2 while providing a refined and validated set of learning outcomes that will be consistently applied across all project activities. The framework integrates the strengths identified across partner institutions, addresses the curricular gaps revealed in WP2-A1, and establishes a balanced combination of foundational knowledge, practical skills, higher-order competences and responsible AI principles.

Beyond defining the final project ILOs themselves, this section also analyses their educational structure. The framework is examined from complementary perspectives, including Bloom's taxonomy, competence-domain mapping and overall educational balance. Together, these analyses demonstrate that the selected ILOs form a coherent, measurable and pedagogically sound foundation for the subsequent development of MOOCs, learning activities and assessment strategies within the TAI project.

2.1 Final project ILO set

The final project ILO set represents the principal outcome of WP2-A3. It is derived from the consolidated desired ILO framework developed in WP2-A2 and constitutes the common educational reference that will be used throughout the remaining project activities, particularly in the design and development of the TAI MOOCs and associated teaching materials.

The final project ILOs are organised into six thematic categories that collectively cover the essential dimensions of contemporary AI education, ranging from fundamental AI concepts and advanced learning paradigms to model development, deployment, application-oriented problem solving and responsible AI. Together, these categories provide a balanced framework that combines conceptual understanding, technical skills, higher-order competences and ethical awareness.

To ensure consistency, transparency and assessability, all ILOs follow a common formulation based on the principles established during the consolidation process in WP2-A2:

- learner-centred wording;

- one dominant Bloom action verb per learning outcome;
- one clearly measurable achievement per statement;
- concise, unambiguous and assessable phrasing.

Accordingly, every learning outcome follows the standard formulation:

"By the end of the module, the learner will be able to..."

The final project ILO set presented below serves as the common educational framework for the TAI project. While individual MOOCs or teaching modules will typically address only a subset of these learning outcomes, the complete portfolio of educational materials developed within the project is expected to collectively cover the entire framework.

Table 1. Final project ILOs

Code	Category	Final project ILO
ILO-1	Core AI and Machine Learning	By the end of the module, the learner will be able to **explain** the main paradigms, concepts and algorithm families of artificial intelligence and machine learning.
ILO-2	Core AI and Machine Learning	By the end of the module, the learner will be able to **apply** standard supervised and unsupervised learning methods to well-defined data analysis problems.
ILO-3	Core AI and Machine Learning	By the end of the module, the learner will be able to **compare** alternative model families, assumptions and performance criteria for a given AI task.
ILO-4	Advanced and Emerging AI Paradigms	By the end of the module, the learner will be able to **explain** the principles of advanced AI paradigms, including deep learning, transfer learning, self-/semi-supervised learning and reinforcement learning.
ILO-5	Advanced and Emerging AI Paradigms	By the end of the module, the learner will be able to **evaluate** the suitability of different modern learning paradigms for problems with limited labels, sequential data, interaction or domain adaptation requirements.

Code	Category	Final project ILO
ILO-6	Advanced and Emerging AI Paradigms	By the end of the module, the learner will be able to **apply** an advanced AI method to solve a domain-relevant problem.
ILO-7	Model Development, Evaluation, and Explainability	By the end of the module, the learner will be able to **prepare** data for AI modelling through cleaning, transformation, feature engineering and appropriate data partitioning.
ILO-8	Model Development, Evaluation, and Explainability	By the end of the module, the learner will be able to **evaluate** AI models using suitable metrics, validation strategies and error-analysis procedures.
ILO-9	Model Development, Evaluation, and Explainability	By the end of the module, the learner will be able to **analyse** model behaviour using explainability and interpretability techniques.
ILO-10	Model Development, Evaluation, and Explainability	By the end of the module, the learner will be able to **improve** model robustness through tuning, regularisation and appropriate handling of data imbalance or uncertainty.
ILO-11	AI deployment, maintenance, and reproducibility	By the end of the module, the learner will be able to **package** an AI model into a reproducible workflow, application or service.
ILO-12	AI deployment, maintenance, and reproducibility	By the end of the module, the learner will be able to **reproduce** experimental results using versioned code, documented settings and managed data resources.
ILO-13	AI deployment, maintenance, and reproducibility	By the end of the module, the learner will be able to **analyse** deployed model performance and identify possible failure modes, drift or monitoring needs.
ILO-14	Application-Oriented ILOs (Engineering and Industry)	By the end of the module, the learner will be able to **formulate** an engineering or industrial problem as an AI task, including appropriate data, constraints and evaluation criteria.

Code	Category	Final project ILO
ILO-15	Application-Oriented ILOs (Engineering and Industry)	By the end of the module, the learner will be able to **design** an AI-based solution for a real-world application such as predictive maintenance, quality control, digital twins or intelligent control.
ILO-16	Application-Oriented ILOs (Engineering and Industry)	By the end of the module, the learner will be able to **integrate** models, data pipelines and domain requirements into a functional prototype, workflow or case-based solution.
ILO-17	Responsible AI and Societal Impact	By the end of the module, the learner will be able to **evaluate** AI solutions with respect to fairness, privacy, transparency and relevant legal or regulatory requirements.
ILO-18	Responsible AI and Societal Impact	By the end of the module, the learner will be able to **assess** the societal and environmental implications of AI deployment in a given context.

Interpretation of the final project ILO set

The final project ILO set provides a balanced educational framework that integrates the key dimensions of contemporary AI education, combining foundational knowledge, technical expertise, practical application and responsible AI principles. The framework has been designed to address the needs identified in WP2-A1 while preserving the common educational vision established through the consolidation process in WP2-A2.

The first category establishes a solid foundation in core AI and machine learning concepts and methods. The second extends this foundation by introducing advanced and emerging AI paradigms that were identified as underrepresented in existing curricula. The third category strengthens learners' ability to develop, evaluate and interpret AI models, while the fourth expands these competencies to include deployment, reproducibility and lifecycle management. The fifth category focuses on applying AI methods to realistic engineering and industrial problems, ensuring that learners can transfer technical knowledge into practical solutions. Finally, the sixth category embeds responsible AI principles throughout the educational framework by addressing ethical, legal, societal and environmental considerations.

Taken together, the final project ILOs define a coherent progression from conceptual understanding to practical implementation, critical evaluation and solution design. They

provide a common educational reference for all teaching materials developed within the TAI project, ensuring consistency across MOOCs while supporting the development of technically competent, application-oriented and responsible AI practitioners.

2.2 Mapping to Bloom taxonomy levels

To ensure educational coherence and a logical progression of learning, **the final project ILO framework** was mapped to Bloom's taxonomy. The distribution across cognitive levels was designed deliberately to reflect the educational objectives of the TAI project rather than being derived mechanically from the wording of individual learning outcomes. Consistent with the findings of WP2-A1, the framework places greater emphasis on higher-order cognitive skills, progressing from **Apply** and **Analyse** towards **Evaluate** and **Create**, while retaining a limited number of **Understand**-level outcomes to provide the necessary conceptual foundation.

Table 2. Distribution of final project ILOs across Bloom levels

Bloom level	No. of ILOs	ILO codes	Role in the curriculum
Understand	2	ILO-1, ILO-4	Establishes conceptual grounding in core and advanced paradigms
Apply	5	ILO-2, ILO-6, ILO-7, ILO-11, ILO-12	Supports practical implementation, experimentation and workflow execution
Analyse	4	ILO-3, ILO-9, ILO-13, ILO-14	Develops diagnostic, interpretive and problem-structuring abilities
Evaluate	4	ILO-5, ILO-8, ILO-17, ILO-18	Strengthens critical judgement, suitability assessment and responsible decision-making
Create	3	ILO-10, ILO-15, ILO-16	Supports design, synthesis and solution-building in real-world contexts
Total	**18**		

Distribution across cognitive levels

The resulting distribution demonstrates a clear emphasis on higher-order cognitive performance. Only two ILOs are assigned to the Understand level, reflecting the fact that the planned MOOCs are intended to complement rather than duplicate the introductory AI

content already available across partner institutions. Instead, most learning outcomes are concentrated at the **Apply**, **Analyse**, **Evaluate** and **Create** levels, supporting the development of practical, transferable and professionally relevant AI competences.

This distribution is pedagogically appropriate for the TAI project for several reasons. First, it aligns with the project's objective of developing learners' ability to apply, evaluate and create AI solutions rather than merely acquiring conceptual knowledge. Second, it reflects the conclusions of WP2-A1, which showed that many existing curricula already provide a solid foundation in classical AI and machine learning, making advanced competencies the primary added value of the TAI MOOCs. Third, it facilitates the design of authentic assessment activities, since learning outcomes at these cognitive levels can be directly evaluated through practical exercises, case studies, critical analyses and project-based work.

Ensuring progression and balance

The progression embedded within the final project ILO set is intentional and defines a coherent learning pathway:

- learners first **understand** core and advanced concepts;
- then **apply** methods and workflows;
- then **analyse** model behaviour, deployment issues and real-world problems;
- then **evaluate** methods, risks and implications;
- and finally **create** robust, application-oriented solutions.

This progression ensures that the educational resources developed within the TAI project are neither excessively theoretical nor narrowly focused on tool usage. Instead, they promote the balanced development of conceptual understanding, technical proficiency, critical thinking and solution design.

The distribution across Bloom's taxonomy is also important from a consortium perspective. Partner institutions contribute complementary strengths, ranging from theoretical foundations and methodological expertise to engineering applications and responsible AI. The Bloom-level distribution therefore serves not only as an instructional design tool but also as a validation of the final project ILO framework, ensuring a balanced representation of different educational perspectives without overemphasising any single cognitive level.

2.3 Mapping to competence domains

In addition to its alignment with Bloom's taxonomy, the **final project ILO framework** was analysed with respect to the three competence domains commonly used in European higher education: **Knowledge**, **Skills** and **Competences**. This complementary perspective provides a

broader understanding of the educational focus of the final project ILOs by identifying the primary type of learning they are intended to promote. For the purposes of this report, each ILO was assigned to the competence domain that best reflects its dominant educational function, while recognising that several learning outcomes naturally span more than one domain.

Definitions used in this report

- **Knowledge** refers to the acquisition and understanding of conceptual and theoretical principles that form the foundation of AI and machine learning.
- **Skills** refer to the ability to perform technical, methodological and procedural tasks using appropriate AI methods, tools and workflows.
- **Competences** refer to the ability to apply knowledge and skills responsibly, autonomously and effectively in complex real-world contexts, integrating technical expertise with critical judgement, problem-solving and ethical considerations.

Table 3. Mapping of final project ILOs to competence domains

Competence domain	ILO codes	Dominant focus
Knowledge	ILO-1, ILO-4	Core and advanced conceptual understanding
Skills	ILO-2, ILO-6, ILO-7, ILO-8, ILO-9, ILO-10, ILO-11, ILO-12, ILO-13	Technical execution, experimentation, analysis, reproducibility and deployment-related practice
Competences	ILO-3, ILO-5, ILO-14, ILO-15, ILO-16, ILO-17, ILO-18	Judgement, real-world problem framing, design, integration, responsibility and societal awareness

Table 4. Expanded interpretation of competence-domain mapping

Domain	Educational meaning in WP2-A3	Typical evidence of achievement	Related ILOs
Knowledge	Learners understand the conceptual basis of AI paradigms and methods	explanation, conceptual articulation, theoretical interpretation	ILO-1, ILO-4

Domain	Educational meaning in WP2-A3	Typical evidence of achievement	Related ILOs
Skills	Learners can perform concrete AI tasks using appropriate tools and procedures	coding, modelling, validation, explainability analysis, reproducibility tasks, packaging and monitoring exercises	ILO-2, ILO-6, ILO-7, ILO-8, ILO-9, ILO-10, ILO-11, ILO-12, ILO-13
Competences	Learners can frame problems, make justified decisions, integrate methods in context and reflect on wider consequences	case studies, design tasks, project work, critical evaluations, domain-based problem solving	ILO-3, ILO-5, ILO-14, ILO-15, ILO-16, ILO-17, ILO-18

Knowledge / Skills / Competences balance

The mapping demonstrates that the final project ILO framework is intentionally weighted towards Skills and Competences, while maintaining an appropriate level of Knowledge as its conceptual foundation. This distribution is consistent with both the educational objectives of the TAI project and the findings of WP2-A1. As current AI curricula at many partner institutions already provide a solid theoretical basis, the greatest added value of the TAI educational resources lies in strengthening learners' practical abilities, problem-solving skills, critical judgement and capacity to apply AI effectively in diverse contexts.

At the same time, conceptual knowledge remains an essential component of the framework. Two ILOs explicitly establish the theoretical understanding upon which the more advanced practical, analytical and evaluative learning outcomes are built. Without this foundation, the higher-level competences developed throughout the framework would lack coherence and educational progression.

The overall balance can therefore be interpreted as follows:

- **Knowledge** provides the conceptual foundation;
- **Skills** provide the technical and methodological capability to develop and apply AI solutions;
- **Competences** provide the capacity to use AI effectively, critically and responsibly in complex real-world contexts.

This balanced distribution confirms that the final project ILO framework extends beyond a collection of technical learning objectives. Instead, it establishes a comprehensive educational framework that integrates theoretical understanding, practical capability and responsible professional practice. As such, it provides a solid pedagogical foundation for the design of the TAI MOOCs and associated teaching materials.

2.4 Summary

The final project ILO framework represents the principal outcome of WP2-A3 and establishes the common educational reference for all subsequent teaching and learning activities within the TAI project. Building upon the consolidated desired ILO framework developed in WP2-A2, this section has presented the final project ILO set together with its pedagogical validation through Bloom's taxonomy and competence-domain analyses.

The combined analyses demonstrate that the framework provides a coherent progression across cognitive levels while maintaining a balanced distribution of knowledge, skills and competences. This confirms that the final project ILOs form a comprehensive educational framework that supports both conceptual understanding and the development of practical, application-oriented and responsible AI capabilities.

The validated framework provides a robust foundation for the design of the TAI MOOCs, learning activities and assessment methods in WP5, while also offering a transparent and consistent educational reference for students, teachers, project partners, reviewers and other external stakeholders.

3. Alignment with identified gaps

This section examines how the final project ILO framework addresses the curricular gaps identified in WP2-A1. While Chapter 2 presented the final project ILO set and validated its pedagogical structure through Bloom's taxonomy and competence-domain analyses, the purpose of this chapter is to evaluate its strategic relevance by demonstrating how the adopted learning outcomes respond to the limitations identified in existing AI curricula across the partner institutions.

The analysis conducted in WP2-A1 revealed a clear imbalance between the strong coverage of classical AI and machine learning foundations and the comparatively limited emphasis on advanced AI paradigms, AI deployment, application-oriented learning and responsible AI. In addition, inconsistencies in ILO formulation and a relatively weak focus on higher-order cognitive skills were identified as factors limiting the consistency and educational effectiveness of existing curricula.

Building upon the consolidated desired ILO framework developed in WP2-A2, the final project ILO framework has been designed to address these shortcomings. Rather than replicating areas that are already well represented within partner institutions, it strengthens competencies in strategically important areas while improving the clarity, measurability and educational progression of the learning outcomes. The following subsections therefore examine how the final project ILOs respond to each of the identified curricular gaps, demonstrating that the framework provides a balanced, modern and pedagogically coherent foundation for AI education within the TAI project.

3.1 Coverage of advanced AI paradigms

One of the most significant gaps identified in WP2-A1 was the limited and uneven coverage of advanced AI paradigms across the partner institutions. While classical supervised learning is generally well represented, more recent approaches—such as deep learning, transfer learning, self-supervised and semi-supervised learning, and reinforcement learning—are addressed inconsistently or only to a limited extent. This creates a gap between existing curricula and contemporary AI practice, in which these paradigms play an increasingly important role.

The final project ILO framework addresses this gap through a dedicated thematic category and the corresponding learning outcomes, ILO-4, ILO-5 and ILO-6. Together, these outcomes extend learners beyond basic familiarity by requiring them to understand, apply and

critically evaluate modern AI methods. In this way, the framework ensures that advanced AI paradigms are treated as an integral component of the TAI educational portfolio rather than as optional or peripheral topics.

Targeted ILO coverage

ILO code	Contribution to gap coverage
ILO-4	Establishes understanding of advanced paradigms (deep learning, transfer learning, self-/semi-supervised learning, reinforcement learning)
ILO-5	Introduces critical evaluation of paradigm suitability based on problem context
ILO-6	Ensures practical application of advanced methods in domain-relevant scenarios

Together, these learning outcomes establish a deliberate progression from **conceptual understanding**, through **critical comparison** and method selection, to **practical implementation**. This progression is consistent with the higher cognitive levels of Bloom's taxonomy and supports the development of both technical proficiency and informed professional judgement.

Shift from classical to modern AI coverage

The inclusion of these ILOs within the final project ILO framework represents a clear shift in educational emphasis:

- from **algorithm-centric learning** → toward **paradigm-aware decision-making**
- from **static datasets and fully labelled data** → toward **realistic data conditions (limited labels, sequential data, domain adaptation)**
- from **isolated methods** → toward **context-driven method selection**

This shift is essential for preparing learners to work with contemporary AI systems, where flexibility and adaptability are required.

Integration with other ILO categories

Importantly, advanced AI paradigms are not treated as an isolated topic. Their integration is reinforced across multiple categories:

- **Model development, evaluation, and explainability**
  - applying and analysing deep learning models

    - evaluating performance and robustness
- **Application-oriented ILOs**
    - using advanced methods in industrial and engineering contexts
- **AI deployment, maintenance, and reproducibility**
    - transitioning advanced models into production environments

This integration ensures that learners do not merely acquire theoretical knowledge about advanced AI paradigms, but also develop the ability to apply, evaluate and deploy them in realistic scenarios. It also strengthens the coherence of the framework by connecting advanced methods with the broader AI development lifecycle.

Addressing uneven partner coverage

The WP2-A1 analysis showed that some partners already include elements of deep learning and related methods, while others focus more strongly on classical or theoretical aspects. The final project ILO framework therefore serves two purposes:

- **for institutions with more advanced existing coverage** → provide a structured way to deepen and standardise coverage
- **for institutions with more limited existing coverage** → introduce essential modern paradigms in a consistent and accessible way

This contributes to harmonisation across the consortium while respecting existing expertise.

Expected impact

By explicitly embedding advanced AI paradigms within the final project ILO framework, WP2-A3 ensures that the educational materials developed in subsequent project activities will:

- reflect **current technological developments in AI**
- prepare learners for **real-world challenges involving complex data and models**
- support progression toward **higher-order competencies (analysis, evaluation, design)** ,
- establish **links between advanced AI methods, practical application and deployment**.

Overall, this analysis confirms that the final project ILO framework does not merely add selected modern topics to existing curricula. Instead, it provides a systematic basis for strengthening and modernising AI education in alignment with current academic practice, technological development and professional requirements.

3.2 Integration of AI deployment and management

A major gap identified in WP2-A1 is the limited coverage **of AI deployment and model lifecycle management** across partner curricula. While most institutions provide strong training in model development within controlled environments (e.g., notebooks), there is significantly less emphasis on how models are **packaged, deployed, monitored and maintained** in real-world systems. This creates a disconnect between academic training and industry expectations, where the full lifecycle of AI systems is critical.

The **final project ILO framework** addresses this gap through a dedicated thematic category and the corresponding learning outcomes, ILO-11, ILO-12 and ILO-13. These outcomes explicitly introduce competencies related to deployment, reproducibility, monitoring and maintenance.

Targeted ILO coverage

ILO code	Contribution to gap coverage
ILO-11	Focuses on packaging models into deployable and reproducible workflows or services
ILO-12	Ensures reproducibility through version control, documentation and experiment management
ILO-13	Introduces monitoring and analysis of deployed model performance, including failure modes and drift

These ILOs collectively extend the AI learning process beyond model development toward **end-to-end system lifecycle management**.

From experimental models to production systems

The inclusion of ILOs related to AI deployment and model lifecycle management introduces a fundamental shift:

- from **notebook-based experimentation** → toward **deployable systems**
- from **one-off model training** → toward **repeatable and versioned workflows**
- from **static evaluation** → toward **continuous monitoring and maintenance**

This reflects the reality of modern AI development, where models must operate reliably in dynamic environments and over extended periods.

Core competencies introduced

The ILOs in this category promote several key competencies:

- **Reproducibility**
  - structuring experiments so results can be replicated
  - managing code, data and configuration versions
- **Deployment**
  - packaging models as APIs, services or applications
  - understanding runtime environments and dependencies
- **Monitoring and maintenance**
  - detecting performance degradation and data drift
  - identifying failure modes and updating models accordingly

These competencies are essential for bridging the gap between academic learning and professional AI practice.

Integration with other ILO categories

The dimension related to AI deployment and model lifecycle management is tightly connected with other parts of the ILO framework:

- **Model development, evaluation, and explainability**
  - provides the validated models that are later deployed
- **Application-oriented ILOs**
  - ensures that deployed systems are aligned with real-world requirements
- **Responsible AI**
  - links deployment with accountability, transparency and compliance

This integration ensures that deployment is not treated as a technical afterthought, but as an **integral part of the AI lifecycle**.

Addressing consortium-level gaps

WP2-A1 showed that only a small number of courses across partners touch upon deployment-related topics, and even then often in a limited or implicit manner. The explicit ILOs related to AI deployment and model lifecycle management therefore serve to:

- **standardise expectations across institutions**
- ensure that all learners gain at least **basic deployment literacy**
- provide a foundation for more advanced or specialised modules

This is particularly important for aligning educational outcomes with labour market needs, where competencies related to AI deployment, monitoring, maintenance, and model lifecycle management are increasingly in demand.

Expected impact

By embedding AI deployment and model lifecycle management into the final project ILO framework, WP2-A3 ensures that learners are prepared not only to develop AI models, but also to **operate, monitor and maintain them in realistic environments**. This contributes to:

- improved **employability and industry readiness**
- better understanding of **AI system lifecycle complexity**
- stronger alignment between **academic training and professional practice**

Overall, this subsection demonstrates that the final project ILO framework addresses one of the most critical gaps in current AI education by explicitly incorporating **deployment, reproducibility and operational thinking** into the learning outcomes.

3.3 Inclusion of industrial applications

Another key gap identified in WP2-A1 is the relatively limited and uneven inclusion of **application-oriented AI learning**, particularly in engineering and industrial contexts. While some partner institutions provide domain-specific courses (e.g., robotics, intelligent systems, control), many curricula remain focused on generic algorithmic tasks, with insufficient emphasis on solving **real-world problems in concrete domains**.

The final project ILO framework addresses this gap through a dedicated thematic category and the corresponding learning outcomes, ILO-14, ILO-15 and ILO-16. These outcomes explicitly focus on problem formulation, solution design and the integration of AI methods into functional industrial and engineering applications.

Targeted ILO coverage

ILO code	Contribution to gap coverage
ILO-14	Focuses on formulating real-world problems as AI tasks, including data, constraints and evaluation criteria
ILO-15	Addresses the design of AI-based solutions for industrial and engineering applications
ILO-16	Ensures integration of models, data and domain requirements into functional prototypes or workflows

Together, these ILOs move beyond isolated technical tasks toward **holistic, problem-driven AI application**.

From generic tasks to domain-driven problem solving

The inclusion of application-oriented ILOs introduces a clear shift:

- from **toy problems and benchmark datasets** → toward **real-world industrial scenarios**
- from **method-centric learning** → toward **problem-centric solution design**
- from **isolated modelling tasks** → toward **integrated systems addressing domain constraints**

This shift is essential for preparing learners to operate in professional environments where AI is applied to complex, domain-specific challenges.

Key application domains addressed

The ILOs are intentionally formulated in a way that supports multiple domains relevant to the consortium, including:

- **manufacturing and industrial processes**
  - predictive maintenance
  - quality control and inspection
  - process optimisation
- **engineering systems**
  - intelligent control systems
  - robotics and autonomous systems

    - sensor data analysis
- **data-driven business and operational contexts**
    - decision support systems
    - anomaly detection
    - forecasting and optimisation

The framework does not prescribe a single domain, but ensures that learners develop the **ability to transfer AI knowledge across application contexts**.

Integration with partner strengths

This thematic category builds on complementary strengths across the consortium. Several partner institutions contribute substantial expertise in engineering, industrial systems, applied machine learning, problem formulation and system integration. The framework combines these perspectives into a common set of educational expectations while also enabling institutions with a stronger theoretical orientation to connect foundational knowledge with realistic applications.

This approach supports the use of existing institutional expertise without making the final project ILO framework dependent on any single partner or application domain.

Integration with other ILO categories

Application-oriented ILOs act as a **central integration point** within the overall framework:

- **Core and advanced AI methods**
    - provide the techniques used in applications
- **Model development, evaluation, and explainability**
    - ensures that solutions are technically sound and validated
- **AI deployment, maintenance, and reproducibility**
    - supports transition from prototype to operational system
- **Responsible AI**
    - ensures that applications are ethically and legally appropriate

This positioning ensures that application-oriented learning is not isolated, but embedded within the full AI lifecycle.

Addressing uneven coverage across the consortium

WP2-A1 showed that application-oriented content is often concentrated in specific courses or partners, rather than systematically integrated across curricula. The inclusion of explicit ILOs therefore:

- **ensures minimum application competence for all learners**
- promotes **consistency across institutions**
- supports the development of **practice-oriented MOOCs**

This is particularly important for interdisciplinary programmes, where students must be able to connect AI methods with domain knowledge.

Expected impact

By embedding industrial and engineering applications into the final project ILO framework, WP2-A3 ensures that learners will be able to:

- **translate real-world problems into well-defined AI tasks;**
- **design AI-based solutions that account for practical requirements and constraints;**
- **integrate data, models and domain knowledge into functional solutions;**
- **develop transferable problem-solving competences applicable across multiple contexts.**

Overall, this analysis confirms that the final project ILO framework strengthens the practical relevance of AI education within the consortium and improves alignment with professional requirements, where the ability to apply AI effectively in realistic contexts is a core competence.

3.4 Embedding responsible AI across modules

WP2-A1 identified a significant and systemic gap in the **inconsistent treatment of responsible AI topics** across partner institutions. While ethical, legal and societal aspects of AI are increasingly important—particularly in the European context—they are often addressed only marginally, treated as optional topics, or confined to isolated courses. This results in a fragmented understanding, where technical competencies are not sufficiently connected to their broader implications.

The **final project ILO framework** addresses this gap through the dedicated learning outcomes ILO-17 and ILO-18, while also integrating responsible AI considerations across the other thematic categories. This dual approach ensures both explicit visibility and systematic integration.

Targeted ILO coverage

ILO code	Contribution to gap coverage
ILO-17	Focuses on evaluating AI systems in terms of fairness, privacy, transparency and regulatory compliance
ILO-18	Addresses broader societal and environmental impacts of AI deployment

These ILOs elevate responsible AI from a peripheral topic to a **core competency within the framework**.

From isolated topic to cross-cutting dimension

A central principle of the final project ILO framework is that responsible AI should not be treated solely as a separate concluding topic, but as **a cross-cutting dimension integrated throughout the learning process**. This represents a shift:

- from **add-on ethics modules** → toward **continuous ethical awareness**
- from **abstract discussion** → toward **contextual evaluation within technical tasks**
- from **compliance-only perspective** → toward **critical and responsible decision-making**

This approach aligns with current best practices in AI education and with emerging regulatory expectations (e.g., EU AI-related frameworks).

Core responsible AI competencies

The ILOs in this category ensure that learners develop the ability to:

- **evaluate fairness and bias**
  - identify potential discrimination in data and models
  - assess the impact of model decisions on different groups
- **address privacy and legal constraints**
  - understand data protection principles (e.g., GDPR-related aspects)
  - evaluate compliance with regulatory requirements

- **assess transparency and explainability**
  - consider whether model decisions can be interpreted and justified
  - connect explainability techniques with accountability
- **reflect on societal and environmental impact**
  - assess broader consequences of AI deployment
  - consider sustainability and long-term implications

Integration across ILO categories

Responsible AI is reinforced across multiple parts of the framework:

- **Model development, evaluation, and explainability**
  - links explainability and robustness with ethical evaluation
- **AI deployment, maintenance, and reproducibility**
  - connects monitoring with accountability and compliance
- **Application-oriented ILOs**
  - ensures that real-world solutions consider societal impact
- **Advanced AI paradigms**
  - supports critical evaluation of complex and opaque models

This integration ensures that responsible AI is not only taught explicitly but also applied within technical, analytical and application-oriented learning activities.

Addressing consortium-level inconsistencies

WP2-A1 showed that responsible AI topics are systematically included in only a limited number of courses across the partner institutions, while elsewhere they are addressed indirectly, inconsistently or not at all. The inclusion of explicit responsible AI learning outcomes therefore:

- establishes **common minimum expectations across the consortium**;
- ensures that **all learners acquire foundational responsible AI competences**;
- supports consistent **integration of ethical, legal, societal and environmental considerations into teaching activities**;
- provides a **basis for more advanced or specialised learning content**.

This also strengthens the alignment of the TAI educational framework with European priorities concerning trustworthy and responsible AI.

Expected impact

By embedding responsible AI throughout the ILO framework, WP2-A3 ensures that learners:

- develop **critical awareness of AI implications,**
- are able to **evaluate and justify AI solutions beyond technical performance alone,**
- understand the importance of **ethical, legal and societal considerations**,
- make more **responsible and accountable decisions throughout the AI lifecycle**.

Overall, this analysis confirms that the final project ILO framework transforms responsible AI from an optional or isolated topic into an integral dimension of AI education. It supports the development of graduates who are not only technically competent, but also capable of designing, evaluating and applying AI systems responsibly and accountably.

3.5 Improvement of ILO clarity and assessability

In addition to content-related gaps, WP2-A1 identified several structural weaknesses in the formulation of Intended Learning Outcomes (ILOs), including heterogeneous formats, frequent use of vague verbs, compound statements and weak alignment with Bloom's taxonomy. These issues reduce the effectiveness of ILOs as tools for curriculum design, teaching and assessment, making it difficult to interpret learning expectations and to evaluate student achievement consistently.

The final project ILO framework addresses these shortcomings through the systematic application of standardised formulation principles and explicit alignment with Bloom's taxonomy. As a result, the final project ILOs are not only **comprehensive in terms of content**, but also **clearer, more measurable and easier to align with teaching and assessment activities**.

Key improvements introduced

The following design principles were consistently applied across all final project ILOs:

- **Single-verb structure**
  - each ILO contains one dominant, measurable action verb
  - eliminates ambiguity in expected performance
- **Standardised syntax**

- all ILOs follow the same formulation:

  "By the end of the module, the learner will be able to…"

- ensures consistency across courses and institutions

- **Clear and measurable wording**
  - use of action verbs such as:
    - *apply, analyse, evaluate, design, integrate*
  - avoidance of vague expressions like:
    - *understand*, *be familiar with* (unless clearly contextualised)
- **One outcome per statement**
  - compound ILOs split into multiple distinct outcomes
  - improves assessability and alignment with assessment tasks

Comparison with previous ILO formulation practices

Aspect	WP2-A1 findings on existing practice	Final project ILO framework
Structure	heterogeneous, inconsistent	standardised and uniform
Verb usage	vague (e.g., "understand")	measurable (e.g., "apply", "evaluate")
Complexity	compound, multi-action	single-action, focused
Assessability	unclear or implicit	explicit and measurable
Bloom alignment	inconsistent	systematic and intentional

This comparison highlights a clear shift from **descriptive or content-based statements** toward **performance-oriented and assessable outcomes**.

Alignment with assessment design

Improved ILO clarity directly supports the design of assessment methods. Each final project ILO can now be linked to specific types of assessment:

ILO type	Typical assessment method
Apply / Implement	coding tasks, practical exercises

ILO type	Typical assessment method
Analyse	case studies, error analysis
Evaluate	comparative studies, critical reports
Create / Design	project work, system development

This alignment ensures that:

- learning activities are **goal-oriented**,
- assessments are **valid and consistent**,
- outcomes are **transparent to students and instructors**.

Support for cross-institutional comparability

One of the key challenges identified in WP2-A1 was the difficulty of comparing ILOs across institutions due to inconsistent wording and structure. The standardisation introduced in WP2-A2 enables:

- **direct comparison of outcomes across courses and partners**
- easier **aggregation and reporting at project level**
- improved **transferability of teaching materials**

This is particularly important in a multi-partner project, where alignment and coherence are essential.

Contribution to overall curriculum quality

The improvement in ILO clarity is not only a technical refinement, but a fundamental enhancement of curriculum design. Clear and assessable ILOs:

- make learning expectations **transparent to students**
- support instructors in **designing aligned teaching activities**
- enable more reliable **evaluation of learning outcomes**

In addition, the consistent use of Bloom's taxonomy ensures that ILOs reflect a deliberate progression of cognitive complexity, rather than an arbitrary mix of levels.

Expected impact

By addressing the structural weaknesses identified in WP2-A1, the final project ILO framework ensures that the adopted learning outcomes are:

- clear and consistently formulated;
- measurable and assessable;
- aligned with teaching and assessment methods;
- comparable across partner institutions;
- suitable for use as a common reference in the development of the TAI MOOCs.

Overall, this analysis confirms that the final project ILO framework improves not only the content of AI education, but also the way in which learning expectations are *defined*, *communicated* and *evaluated*. It therefore contributes to a more coherent, transparent and educationally effective foundation for the subsequent project activities.

4. Implications for MOOC development (WP5)

The final project ILO framework established in WP2-A3 provides the common educational foundation for the design and development of the TAI MOOCs in WP5. While the preceding chapters presented the final project ILOs and evaluated their pedagogical structure and alignment with the gaps identified in WP2-A1, this chapter translates the resulting framework into practical implications for the organisation, content, delivery and assessment of the planned educational materials.

The ILO framework ensures that MOOC development is guided by clearly defined educational objectives rather than solely by the availability of existing content or the individual expertise of partner institutions. In particular, its emphasis on advanced AI paradigms, model development, evaluation, and explainability, deployment and lifecycle management, application-oriented problem solving and responsible AI provides a clear direction for course development. This approach helps ensure that the TAI MOOCs complement existing curricula by strengthening areas that were identified as underrepresented in WP2-A1 rather than duplicating content that is already widely available.

The consistent formulation and thematic organisation of the final project ILOs also support a coherent and modular approach to MOOC development. They provide a common reference for aligning learning objectives, instructional content, learning activities and assessment methods across different modules. At the same time, the framework allows sufficient flexibility for individual MOOCs to address different learner groups, disciplinary contexts and levels of prior knowledge.

The following subsections outline how the final project ILO framework can inform key aspects of MOOC design, including module structure, pedagogical approaches, assessment methods and connections between thematic areas. The proposed structure should be understood as a **recommended implementation model rather than a mandatory course architecture**. It provides one possible way of translating the final project ILOs into a coherent portfolio of MOOCs and learning modules within WP5**.**

4.1 Translation of ILOs into course modules

The final project ILOs provide a structured basis for the design of MOOC modules within WP5. Rather than developing courses in an ad hoc manner, the ILO framework supports a **systematic translation of learning outcomes into coherent and modular learning units**,

ensuring alignment between intended outcomes, instructional content, learning activities and assessment methods.

At the highest level, the six thematic categories of the final project ILO framework can serve as the **principal building blocks for the MOOC structure**. Depending on the required scope, target audience and level of complexity, each category may be addressed through a single module or distributed across several interconnected modules.

From ILO categories to MOOC modules

ILO Category	Suggested MOOC Module
Core AI and Machine Learning	Foundations of AI and Machine Learning
Advanced AI Paradigms	Deep Learning and Modern AI Methods
Model Development, Evaluation, Explainability	Model Development, Evaluation, and Explainability
AI Deployment, Maintenance, and Reproducibility	From Model to Production (MLOps)
Application-Oriented ILOs	AI in Engineering and Industry
Responsible AI	Responsible and Trustworthy AI

This mapping ensures that each module is **goal-oriented and aligned with clearly defined competencies**, rather than loosely organised around topics.

Mapping individual ILOs to modules

Within each module, individual ILOs define the **learning scope and expected outcomes**.

Module	Related ILOs	Focus
Foundations of AI and ML	ILO-1, ILO-2, ILO-3	Core concepts and basic application
Modern AI Methods	ILO-4, ILO-5, ILO-6	Advanced paradigms
Model Development & Evaluation	ILO-7, ILO-8, ILO-9, ILO-10	Data, modelling, explainability

Module	Related ILOs	Focus
MLOps and Deployment	ILO-11, ILO-12, ILO-13	Deployment and lifecycle
AI in Industry	ILO-14, ILO-15, ILO-16	Real-world problem solving
Responsible AI	ILO-17, ILO-18	Ethics, legal, societal aspects

This ensures that **each module has a clear purpose and measurable outcomes**, facilitating both teaching and assessment design.

Granularity and modular design

The ILO framework supports flexible module design at different levels of granularity:

- **Micro-modules (short units)**
  - 1–2 ILOs per unit
  - focused on specific skills (e.g., model evaluation, explainability)
- **Standard modules**
  - 3–5 ILOs
  - balanced combination of knowledge and skills
- **Integrated modules**
  - multiple ILO categories
  - suitable for project-based or capstone courses

This flexibility allows MOOCs to be adapted to:

- different learner levels
- varying time constraints
- different delivery formats (self-paced, blended learning)

Ensuring alignment with Bloom progression

The translation from ILOs to modules also ensures a **coherent cognitive progression**:

- introductory modules → **Apply / Understand**
- intermediate modules → **Analyse**
- advanced modules → **Evaluate / Create**

This progression can be reflected in course sequencing, where learners gradually move from:

- foundational understanding
- to practical implementation
- to critical evaluation and design

Integration across modules

Although modules are defined separately, the ILO framework ensures strong interconnections:

- **Model development** modules feed into **deployment modules**
- **Advanced methods** are applied in **application-oriented modules**
- **Responsible AI** is embedded across all modules

This supports a **learning pathway approach**, rather than isolated course units.

Implications for content development

The structured mapping from ILOs to modules has several practical implications:

- ensures **consistency across partner-developed MOOCs**
- reduces redundancy by avoiding duplication of topics
- supports **clear definition of module scope and learning objectives**
- facilitates **collaborative course development**, where partners can contribute modules aligned with their expertise

Expected impact

By translating ILOs into modular course structures, WP2-A3 helps ensure that MOOC development in WP5 is:

- **goal-driven rather than content-driven**
- **coherent across institutions**
- **aligned with identified gaps in AI education**
- **adaptable to different learning contexts**

Overall, this approach provides a robust foundation for designing MOOCs that are both pedagogically sound and practically relevant.

4.2 Suggested MOOC structure and sequencing

Building upon the final project ILO framework, this report proposes a coherent structure and sequencing of the TAI MOOCs that reflects both the educational priorities established in WP2-A3 and the curricular gaps identified in WP2-A1. Rather than developing a collection of independent courses, the MOOCs are intended to form a progressive learning pathway that guides learners from foundational AI competencies towards advanced, application-oriented, deployable and responsible AI practice.

This recommended learning pathway can be conceptually organised into three interconnected strands:

- **Modernising the AI foundation**
- **Deployable and applied AI**
- **Responsible AI**

These strands should not be interpreted as strictly sequential or independent courses. Instead, they represent complementary layers of learning that progressively build learners' knowledge, skills and competences while reinforcing important cross-cutting themes throughout the educational programme.

Overall MOOC sequencing model

Phase	Strand	Main focus	Related ILO categories (from WP2-A2 report)
Phase 1	Modernizing the AI foundation	Extending classical ML toward modern AI paradigms	5.1, 5.2, 5.3
Phase 2	Deployable and applied AI	Transitioning from models to real-world systems	5.3, 5.4, 5.5
Phase 3	Responsible AI	Embedding ethical, legal and societal considerations	5.6 (cross-cutting)

Phase 1: “Modernizing the AI foundation”

This phase builds on the existing strengths of partner institutions and extends them toward contemporary AI practices. The goal is not to repeat basic ML content, but to **update and expand the core competencies**.

Key elements include:

- reinforcement of:
  - core ML concepts and algorithms
- introduction of:
  - deep learning
  - transfer learning
  - self-/semi-supervised learning
- strengthening:
  - model evaluation
  - explainability and robustness

Relevant ILOs:

- ILO-1 to ILO-10

Expected outcome:

- learners move from **basic application** toward **analytical and evaluative understanding of modern AI methods**

Phase 2: "Deployable and applied AI"

The second phase addresses one of the most critical gaps identified in WP2-A1: the transition from models to **real-world, operational AI systems**.

Key elements include:

- **MLOps and deployment**
  - packaging models
  - version control and reproducibility
  - monitoring and maintenance
- **application-oriented learning**
  - solving real-world engineering and industrial problems
  - integrating models into workflows and systems

Relevant ILOs:

- ILO-7 to ILO-16

Expected outcome:

- learners develop the ability to:
  - **build complete AI solutions**
  - **deploy and maintain them in realistic environments**

This phase is strongly aligned with industry needs and significantly enhances employability.

Phase 3: "Responsible AI"

The third strand focuses on embedding **ethical, legal and societal considerations** throughout the learning process. Importantly, this is not treated as a final standalone module, but as a **cross-cutting dimension** integrated across all phases.

Key elements include:

- fairness and bias evaluation
- privacy and legal compliance
- transparency and explainability
- societal and environmental impact

Relevant ILOs:

- ILO-17, ILO-18

Implementation approach:

- dedicated modules (e.g., "Responsible AI")
- integration into:
  - model evaluation tasks
  - deployment scenarios
  - application case studies

Expected outcome:

- learners develop the ability to:
  - **critically assess AI systems beyond technical performance**
  - **make responsible and accountable decisions**

Integration of strands

Although presented as phases, the three strands are tightly interconnected:

- **Modern AI methods** are applied in **deployment scenarios**

- **Deployment decisions** are evaluated through a **responsible AI lens**
- **Responsible AI principles** influence:
  - model design
  - evaluation criteria
  - system deployment

This ensures that learners experience AI as a **holistic discipline**, rather than a collection of disconnected topics.

Proposed learning pathway

A typical learner progression through the MOOCs could follow this structure:

1. **Foundations and modern AI methods**
2. **Model development, evaluation and explainability**
3. **AI deployment and model lifecycle management**
4. **Application-oriented projects**
5. **Responsible AI (integrated throughout + dedicated module)**

Expected impact

This structured sequencing ensures that the MOOCs:

- **complement existing curricula** rather than duplicate them
- provide a **clear progression of competencies**
- address the **most critical gaps identified in WP2-A1**
- support both **academic learning and practical application**

Overall, the proposed structure transforms the ILO framework into a **coherent educational pathway**, enabling the development of MOOCs that are modern, applicable and aligned with real-world AI practice.

4.3 Alignment with assessment strategies

The final project ILO framework provides a clear foundation for the **design of aligned, transparent and measurable assessment strategies** for the TAI MOOCs developed in WP5. Consistent with the principles of outcome-based education, assessment is not regarded as an independent component of course design but as an integral element that is directly derived from the intended learning outcomes and aligned with the associated learning activities.

A key implication of the framework is that **every ILO should be assessable using appropriate and authentic assessment methods**. This ensures constructive alignment between learning outcomes, instructional activities and assessment tasks, while addressing one of the principal weaknesses identified in WP2-A1: the use of vague, compound or insufficiently measurable learning outcomes that limited consistent assessment across existing curricula.

Constructive alignment of ILOs, activities and assessment

The MOOC design follows the principle of **constructive alignment**, where:

- ILOs define **what learners should achieve**
- learning activities define **how they practice these competencies**
- assessments verify **whether the outcomes are achieved**

This relationship can be summarised as:

Component	Role in MOOC design
ILOs	Define measurable learning targets
Learning activities	Provide opportunities to develop competencies
Assessment methods	Evaluate achievement of outcomes

Mapping ILO types to assessment methods

The standardised ILO structure enables direct mapping to appropriate assessment formats:

ILO type (Bloom level)	Typical assessment strategy	Example
Apply	Practical tasks, coding exercises	Implement a classification model
Analyse	Case studies, error analysis	Diagnose model performance issues

ILO type (Bloom level)	Typical assessment strategy	Example
Evaluate	Critical reports, comparisons	Compare models and justify selection
Create	Projects, system design tasks	Develop an end-to-end AI solution

This mapping ensures that assessment is **valid (measures intended competencies)** and **consistent across modules**.

Assessment strategies for key ILO categories

To reflect the diversity of learning outcomes and competences represented in the final project ILO framework, different thematic categories require different assessment approaches:

- **Core AI concepts and advanced AI paradigms**
    - quizzes and structured problem-solving tasks;
    - practical programming and model implementation assignments;
- **Model development, evaluation, and explainability**
    - experimental reports;
    - model comparison, validation and interpretation tasks;
- **AI deployment, maintenance, and reproducibility**
    - reproducibility exercises;
    - deployment, packaging and workflow implementation assignments;
- **Application-oriented learning**
    - case studies;
    - project-based assignments addressing realistic engineering or industrial problems;

- **Responsible AI**
    - reflective analyses;
    - ethical, legal and societal evaluation of AI systems.

This diversity of assessment methods reflects the broad range of knowledge, skills and competences represented within the final project ILO framework and supports authentic evaluation of learner achievement.

Formative and summative assessment balance

The proposed MOOC design should incorporate both formative and summative assessment components.

Formative assessment should provide continuous feedback through activities such as quizzes, short practical exercises and self-assessment tasks, enabling learners to monitor their progress throughout the learning process.

Summative assessment should evaluate the achievement of the intended learning outcomes at the end of each module through project work, technical reports, practical assignments or examinations, depending on the nature of the learning outcomes being assessed.

This combination supports continuous learning while ensuring reliable evaluation of the competences acquired during each module.

Assessment of higher-order competencies

One of the defining characteristics of the final project ILO framework is its emphasis on higher-order cognitive skills, particularly at the **Analyse**, **Evaluate** and **Create** levels of Bloom's taxonomy. These learning outcomes require assessment methods that extend beyond traditional knowledge tests.

Examples include:

- **Analyse**
    - interpretation of model behaviour
    - identification of errors or limitations
- **Evaluate**

    - comparison of methods
    - justification of decisions
- **Create**
    - design and implementation of AI systems
    - integration of multiple components

Such assessments are typically implemented through:

- **project work,**
- **case-based assignments**,
- **open-ended design and implementation tasks**

Integration of responsible AI in assessment

Responsible AI should not be assessed solely through dedicated ethics-related activities. Instead, ethical, legal and societal considerations should be integrated throughout the assessment strategy.

Examples include:

- evaluating fairness and bias within model comparison exercises;
- assessing privacy and regulatory implications in deployment scenarios;
- considering societal, environmental and stakeholder impacts within project-based assignments.

This integrated approach ensures that responsible AI becomes an inherent part of technical problem solving rather than an isolated learning topic.

Implications for MOOC platforms

The assessment strategy derived from the final project ILO framework also has implications for MOOC implementation:

- need for **automated assessment tools** (quizzes, coding environments)
- support for **peer assessment** (especially for projects)
- integration of **real-world datasets and scenarios**
- possibility of **portfolio-based assessment** (for complex competencies)

These capabilities provide the flexibility required to assess a wide range of learning outcomes while supporting scalable online delivery.

Expected impact

Aligning assessment strategies with the final project ILOs helps ensure that MOOCs developed in WP5:

- provide **clear and measurable learning outcomes**
- support **consistent evaluation across modules and institutions**
- promote **higher-order thinking and real-world problem solving**
- integrate **technical and responsible AI competencies**

Overall, this alignment transforms assessment from a validation step into a **core component of the learning process**, ensuring that the intended competencies are effectively developed and demonstrated.

4.4 Recommendations for teaching methods

The final project Intended Learning Outcomes (ILOs) have direct implications for the selection of **teaching methods and pedagogical approaches** in WP5 MOOCs. Given the strong emphasis on higher-order cognitive skills (Analyse, Evaluate, Create), practical competencies and real-world application, traditional lecture-based approaches alone are not sufficient. Instead, a combination of **active, practice-oriented and learner-centred methods** is required.

Alignment between ILOs and teaching methods

The nature of the ILOs determines the appropriate teaching strategies:

ILO focus	Recommended teaching methods	Purpose
Conceptual understanding	Short lectures, guided explanations	Introduce core ideas and frameworks
Practical skills	Hands-on labs, coding exercises	Develop implementation competence
Analytical skills	Case studies, guided analysis	Support interpretation and diagnosis
Evaluation	Comparative tasks, discussions	Develop critical judgement

ILO focus	Recommended teaching methods	Purpose
Creation	Projects, problem-based learning	Enable design and integration

This alignment ensures that teaching methods actively support the achievement of intended outcomes.

Key recommended teaching approaches

Based on the ILO framework and WP2-A1 findings, the following approaches are recommended:

1. Hands-on, practice-oriented learning

- coding exercises using real datasets
- step-by-step model development tasks
- experimentation with parameters and models

supports:

- Apply and Analyse levels
- development of technical skills

2. Problem-based and project-based learning

- real-world problem scenarios (e.g., predictive maintenance, classification tasks)
- multi-step projects integrating multiple AI techniques

supports:

- Analyse, Evaluate, Create levels
- development of system-level competencies

3. Case-based learning

- analysis of real AI applications
- identification of limitations, biases and trade-offs

supports:

- Evaluate level
- critical thinking and decision-making

4. Iterative learning and experimentation

- repeated cycles of:
  - model building
  - evaluation
  - improvement

supports:

- deeper understanding of model behaviour
- development of robustness and optimisation skills

5. Integration of responsible AI in teaching activities

- embedding ethical considerations in exercises and projects
- discussion of fairness, privacy and societal impact

ensures:

- responsible AI is **practiced**, not only explained

MOOC-specific teaching considerations

Because the TAI MOOCs will be delivered online and asynchronously, several additional design considerations should be taken into account:

- **Short, focused content units**
  - micro-lectures (5–10 minutes)
  - modular structure aligned with ILOs
- **Interactive elements**
  - quizzes embedded in videos
  - coding notebooks and simulations
- **Self-paced learning support**
  - clear instructions and examples
  - optional advanced materials
- **Peer interaction**
  - discussion forums
  - peer review of assignments

These elements can help maintain learner engagement and provide opportunities for active participation despite the scalable and flexible nature of MOOC delivery.

Integration across modules

Teaching methods should support a gradual progression in learner autonomy across the MOOC portfolio:

- **foundational modules** may rely more strongly on guided explanations and structured exercises;
- **intermediate modules** may use semi-structured analytical and implementation tasks;
- **advanced modules** should increasingly incorporate open-ended projects, realistic cases and independent solution design.

This creates a deliberate transition from guided learning towards autonomous and interdisciplinary problem solving.

Role of partner expertise

The diversity of expertise within the consortium can support the collaborative development of high-quality teaching materials. Different partners may contribute theoretical explanations, applied machine learning exercises, engineering cases, deployment workflows, system-integration tasks and responsible AI activities according to their relevant experience.

However, the allocation of teaching-development responsibilities should remain flexible and be determined within WP5. The final project ILO framework should serve as the common reference that ensures consistency across partner contributions, regardless of which institution develops a particular module or activity.

Expected impact

By aligning teaching methods with the final project ILO framework, the TAI MOOCs are expected to:

- support active, applied and learner-centred learning;
- promote higher-order cognitive skills;
- strengthen real-world and interdisciplinary problem solving;

- develop technical, methodological and responsible AI competences;
- support gradual progression from guided instruction to independent solution design.

Overall, these recommendations are intended to ensure that the TAI MOOCs are not only informative, but also engaging, practical and pedagogically aligned with the final project ILOs.

5. Conclusion

This section summarises the key outcomes of WP2-A3 and reflects on their significance for the overall objectives of the TAI project. Building upon the curriculum analysis conducted in WP2-A1 and the consolidated desired Intended Learning Outcomes developed in WP2-A2, WP2-A3 has completed the educational design process by establishing, analysing and validating the final project ILO framework.

The conclusion highlights the main contributions of WP2-A3, its added value in relation to the preceding activities, and its impact on the development of a coherent AI education strategy across the consortium. Particular emphasis is placed on the pedagogical validation of the final project ILO framework and its translation into practical recommendations for the MOOCs and other educational resources to be developed in WP5.

5.1 Summary of key contributions

WP2-A3 represents the final stage of the Intended Learning Outcomes development process within the TAI project. It transforms the consolidated desired ILO framework developed in WP2-A2 into a validated and implementation-oriented final project ILO framework that can serve as a direct educational reference for subsequent project activities.

The key contributions of WP2-A3 can be summarised across several complementary dimensions.

1. Establishment of the final project ILO framework

A primary contribution of WP2-A3 is the establishment of the final project ILO framework, derived from the consolidated desired ILOs developed in WP2-A2 and further examined from pedagogical and implementation perspectives.

The final framework:

- defines clear, measurable and assessable learning outcomes;
- provides a coherent structure for AI education;
- reflects the knowledge, skills and competences required for contemporary AI practice;
- supports consistency across the educational materials developed within the project.

This framework represents the common educational reference for the TAI consortium and provides the foundation for the design of the WP5 MOOCs.

2. Pedagogical validation of the ILO framework

WP2-A3 validates the final project ILO framework through complementary educational analyses.

These include:

- analysis of cognitive levels using Bloom's taxonomy;
- analysis of the balance between knowledge, skills and competences;
- examination of the clarity and assessability of individual learning outcomes;
- evaluation of the progression from foundational understanding to higher-order cognitive skills.

The results confirm that the framework supports a deliberate progression from understanding and application towards analysis, evaluation and creation.

This progression is important for ensuring that the TAI educational resources do not focus only on theoretical knowledge, but also develop practical, analytical and integrative competences.

3. Alignment with identified curricular gaps

A further contribution of WP2-A3 is the systematic examination of how the final project ILO framework addresses the gaps identified during WP2-A1.

The framework strengthens the coverage of:

- **advanced AI paradigms** (e.g., deep learning, transfer learning)

- **AI deployment and model lifecycle management practices**
- **application-oriented and industrial AI use cases**
- **responsible AI and societal impact**
- **explainability and robustness**

This confirms that the final project ILO framework is not merely a harmonised set of learning outcomes, but a **targeted educational response to the weaknesses and development needs identified across the partner curricula**.

4. Translation of ILOs into recommendations for WP5

WP2-A3 also provides practical guidance for the implementation of the final project ILO framework in WP5.

The report establishes links between the ILOs and:

- the structure and sequencing of MOOC modules;
- appropriate assessment strategies;
- teaching methods and learning activities;
- online and asynchronous learning formats;
- the gradual development of learner autonomy.

This supports constructive alignment between intended learning outcomes, teaching activities and assessment tasks.

The recommendations are designed to support consistency across partner-developed materials while remaining sufficiently flexible to accommodate different educational contexts, learner profiles and implementation approaches.

5. Integration of responsible AI across the educational framework

WP2-A3 confirms responsible AI as a cross-cutting dimension of the final project ILO framework.

Responsible AI is not treated only as a separate thematic area, but is integrated into:

- technical model development;
- model evaluation and comparison;
- deployment scenarios;

- project-based assignments;
- discussion of fairness, privacy, transparency and societal impact.

This contributes to the development of learners who are not only technically competent, but also capable of recognising and addressing the broader implications of AI systems.

6. Establishment of a common educational reference for the consortium

The final project ILO framework provides a shared educational reference for all partner institutions.

It supports:

- coherent development of MOOCs and teaching materials;
- comparability of learning expectations across modules;
- collaboration and resource sharing among partners;
- consistent communication of intended competences;
- future adaptation of the developed materials to different educational settings.

Overall, WP2-A3 provides the pedagogical bridge between the design of the desired learning outcomes in WP2-A2 and their implementation in WP5.

5.2 Added value compared to WP2-A1 and WP2-A2

WP2-A3 provides clear added value in relation to both WP2-A1 and WP2-A2. Together, the three activities form a coherent progression from analysis, through educational design, to validation and implementation guidance.

From curriculum analysis to validated educational framework

WP2-A1 primarily focused on:

- mapping existing courses and ILOs;
- identifying strengths and weaknesses;
- detecting inconsistencies in ILO formulation;
- highlighting gaps in content and competences.

WP2-A2 built upon these findings by:

- consolidating partner contributions;
- harmonising and standardising the wording of desired ILOs;
- organising the outcomes into thematic categories;
- establishing a common desired ILO framework.

WP2-A3 completes this process by:

- establishing the final project ILO framework;
- validating it from pedagogical and competence-based perspectives;
- examining its alignment with the gaps identified in WP2-A1;
- translating it into practical recommendations for WP5.

The progression can therefore be summarised as:

- WP2-A1: What is currently taught and what is missing?
- WP2-A2: What should learners know, understand and be able to do?
- WP2-A3: How can these outcomes be validated and translated into effective educational design?

From identified gaps to validated educational responses

WP2-A1 identified several areas in which the existing curricula showed limited or uneven coverage.

These included:

- advanced AI methods;
- deployment and model lifecycle management;
- responsible AI;
- industrial and engineering applications;
- higher-order cognitive skills.

WP2-A2 addressed these gaps by introducing corresponding desired ILOs.

WP2-A3 adds value by demonstrating that these ILOs:

- form a coherent and balanced framework;
- are formulated at appropriate cognitive levels;
- can be assessed through suitable methods;
- can be translated into practical teaching and learning activities;
- provide a meaningful basis for MOOC development.

This means that the gaps identified in WP2-A1 are not only acknowledged or addressed conceptually, but transformed into validated and implementable educational solutions.

From heterogeneous curricula to common implementation principles

WP2-A1 revealed substantial variability among partner institutions in terms of course content, ILO wording, cognitive levels and thematic coverage.

WP2-A2 reduced this variability by creating a harmonised desired ILO framework.

WP2-A3 further strengthens consortium-wide coherence by defining common principles for:

- course and module design;
- assessment alignment;
- teaching-method selection;
- development of higher-order competences;
- integration of responsible AI;
- online delivery and learner progression.

This enables different partners to develop educational materials within a shared pedagogical structure, even when their institutional contexts and areas of expertise differ.

From educational design to practical implementation guidance

The key added value of WP2-A3 lies in moving beyond the definition of learning outcomes.

While WP2-A2 primarily established what the desired learning outcomes should be, WP2-A3 explains how they can guide:

- the organisation of MOOC content;
- the selection of teaching methods;

- the design of formative and summative assessment;
- the development of projects, case studies and practical exercises;
- the progression from guided learning to independent problem solving.

WP2-A3 therefore operationalises the final project ILO framework and makes it directly usable for WP5.

Summary of added value

Dimension	WP2-A1	WP2-A2	WP2-A3
Primary role	Analysis and diagnosis	Consolidation and design	Validation and implementation guidance
Main output	Findings, strengths, and curricular gaps	Consolidated desired ILO framework	Final project ILO framework and recommendations for WP5
Main question	What exists and what is missing?	What should learners achieve?	How should the framework guide educational implementation?
Pedagogical focus	Analysis of current practice	Harmonised formulation of desired outcomes	Bloom analysis, competence mapping and constructive alignment
Contribution to WP5	Identification of educational needs	Definition of desired ILOs	Direct guidance for module design, teaching and assessment
Overall impact	Diagnostic	Prescriptive	Operational and implementation-oriented

Overall, the added value of WP2-A3 lies in transforming the consolidated desired ILO framework into a validated, coherent and practically applicable educational framework.

It completes the progression from analysis to design and from design to implementation, ensuring that the project can move into WP5 with clearly defined educational objectives and consistent pedagogical guidance.

5.3 Impact on consortium-wide AI education strategy

The outcomes of WP2-A3 have a significant impact on the development of a coherent and forward-looking AI education strategy across the TAI consortium.

By validating the final project ILO framework and linking it to practical educational design, WP2-A3 establishes a common foundation for the development, implementation and future adaptation of AI teaching materials across partner institutions.

Establishing a common strategic educational framework

The final project ILO framework defines a shared understanding of what learners should know, understand and be able to demonstrate after completing the TAI educational resources.

It provides:

- a consistent structure for curriculum and module design;
- common expectations regarding learner achievement;
- a shared reference for teaching and assessment;
- a basis for comparing and integrating partner-developed materials.

This reduces fragmentation and enables a more coordinated approach to AI education across the consortium.

Strengthening coherence across partner institutions

The partner institutions differ in their existing curricula, educational traditions, areas of expertise and levels of AI integration.

The final project ILO framework supports coherence by:

- aligning educational objectives across partner contributions;
- establishing common principles for ILO formulation and interpretation;
- supporting comparable assessment expectations;
- promoting consistent progression across cognitive and competence levels.

At the same time, the framework preserves institutional flexibility.

Partners can contribute specialised content and application examples while remaining aligned with the same overall educational objectives.

Supporting curriculum modernisation

The final project ILO framework provides a clear reference for the modernisation of AI education.

In particular, it supports:

- stronger inclusion of advanced AI paradigms;
- integration of deployment and lifecycle-management practices;
- greater use of realistic engineering and industrial applications;
- systematic incorporation of responsible AI;
- stronger emphasis on higher-order cognitive skills;
- closer alignment between theory, practical work and assessment.

These elements can support not only the immediate development of the WP5 MOOCs, but also the future revision of existing courses and study programmes at partner institutions.

Enabling modular and flexible programme design

The thematic structure of the final project ILO framework supports modular educational design.

The resulting MOOCs and learning units may be:

- integrated into existing courses;
- used as standalone learning resources;
- combined into larger learning pathways;
- adapted for blended or online delivery;

- applied in lifelong-learning or professional-development contexts.

This increases the scalability, transferability and long-term usability of the project results.

Enhancing collaboration and resource sharing

A shared ILO framework and common pedagogical principles facilitate deeper collaboration among consortium partners.

They enable:

- joint development of MOOCs and teaching materials;
- reuse and adaptation of learning resources;
- exchange of case studies, datasets and practical exercises;
- coordinated assessment design;
- integration of complementary institutional expertise.

This supports efficient use of consortium resources and improves the overall coherence and quality of project outputs.

Improving transparency and stakeholder communication

The final project ILO framework also improves communication with different stakeholder groups.

For learners, it provides:

- clearer learning expectations;
- better understanding of module objectives;
- greater transparency regarding assessment.

For teachers and course designers, it provides:

- a common basis for selecting content and teaching methods;
- guidance for constructive alignment;

- support for consistent module development.

For external stakeholders, including industry representatives and accreditation bodies, it provides:

- a clearer description of the competences developed;
- stronger evidence of educational relevance;
- improved visibility of the practical and responsible AI orientation of the project.

Long-term strategic impact

The impact of WP2-A3 extends beyond the immediate development of the WP5 MOOCs.

The final project ILO framework can support:

- future curriculum-development cycles;
- updating of teaching materials in response to technological developments;
- development of new interdisciplinary AI modules;
- cooperation in lifelong learning and professional education;
- future joint educational initiatives within and beyond the consortium.

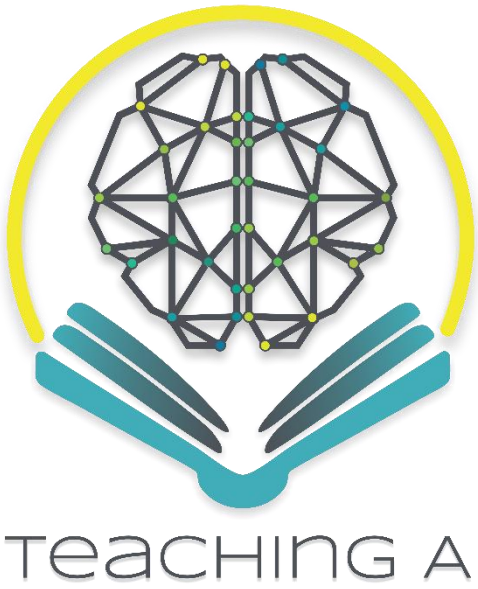
The framework therefore provides a transferable educational model that can contribute to the long-term sustainability of the TAI project results.

Conclusion

Overall, WP2-A3 plays a central role in shaping a unified and implementation-oriented AI education strategy across the consortium.

By establishing and validating the final project ILO framework and translating it into recommendations for MOOC design, teaching and assessment, WP2-A3 enables coordinated educational development while preserving institutional flexibility.

It strengthens curriculum coherence, supports collaboration, promotes modern and responsible AI education, and provides a robust pedagogical foundation for WP5 and for future educational initiatives beyond the duration of the project.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