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D5.2 The AI-boosted augMENTOR platform

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Table of contents

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List of figures

List of tables

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List of acronyms

Acronym	Description
4Cs	Critical Thinking, Communication, Collaboration and Creativity
AI	Artificial Intelligence
API	Application Programming Interface
DAL	Data Access Layer
GMM	Gaussian Mixture Models
HTTP	Hypertext Transfer Protocol
IBL	Inquiry Based Learning
KG	Knowledge Graph
LIME	Local Interpretable Model-agnostic Explanations
LLMs	Large Language Models
MCP	Model Context Protocol
ML	Machine Learning
NaN	Not A Number
RA	Reference Architecture
RF	Random Forest
TA	Technical Architecture
TESA	Technology-augmented Educational Scenarios and e-Activities
TRL	Technology Readiness Level
UMAP	Uniform Manifold Approximation and Projection
USS	User Satisfaction Survey

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Executive summary

The fully interoperable release of the AI-boosted augMENTOR platform presented in this document is a significant milestone for the augMENTOR project. The platform establishes an AI-powered educational system designed to fundamentally enhance digital learning environments by offering intelligent recommendations, comprehensive learner profiling, and explainable decision-support mechanisms for a diverse array of stakeholders, including learners, educators, and policy makers. Its underlying architectural principles prioritize modularity, scalability, and adaptability, which has enabled its successful integration across heterogeneous contexts.

The system's core relies on a layered microservices architecture and a Knowledge Graph that serves as the semantic backbone for data integration and knowledge discovery. Critically, its theoretical design is grounded on the pedagogical framework, explicitly following the Technology-augmented Educational Scenarios and e-Activities (TESA) micro-level of the augMENTOR framework (including pedagogical approach for 21st century skills) to deliver guidelines and recommendations with clear, distinct references. This architecture supports advanced Machine Learning pipelines, which include the Learner Profiling pipeline, a Recommendation Engine, and an Explanation Generator. Extending its utility, the platform also features an integrated Educational Policy Recommendations System designed to offer insights to educational policy makers, course designers, and educational leaders.

The platform's achievement has been confirmed using a mixed-methods assessment including a user satisfaction survey against user, technical, and pedagogical requirements, Key findings indicate high user satisfaction regarding the platform's utility in monitoring student engagement and providing data-driven course design recommendations. To ensure effective utilization and support, the work has been leveraged to produce innovative work methodologies and a dedicated user guide that presents detailed guidance on the entire augMENTOR solution for all target users.

In conclusion this document summarizes the successful delivery of the augMENTOR platform as a whole, presenting all its separate components along with a preliminary evaluation against users' experience as well as technical and operational requirements and key outputs for its effective use by target users.

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1 Introduction

The augMENTOR platform[1] brings together multiple services and AI-based components into a single educational environment. Its objective is to enhance digital learning through intelligent recommendations, learner profiling, explainable feedback and decision-support mechanisms. Its design follows modular and interoperable principles, ensuring scalability, maintainability and adaptability to diverse pilot contexts.

The present deliverable reports on the platform's models, mechanisms and tools developed under tasks T5.2 - T5.4. It presents the integration, consolidation and fully interoperable release of the augMENTOR platform as well as a series of use case scenarios of the foreseen solution's, supporting the formation of advanced education and training methodologies produced through the work done in T5.5. It is the second key output of WP5, following D5.1, which documented data mapping and Knowledge Graph (KG) orchestration.

1.1 Deliverable scope

D5.2 aims to report on the development of the augMENTOR platform, its models, mechanisms and tools. Chapter 2 introduces the platform architecture and presents the updated KG. Chapter 3 analyses the Machine Learning (ML) pipelines for knowledge discovery covering the work done in T5.2 and T5.3. Chapter 4 describes the decision and policy making components (covering the work done T5.4). Chapter 5 provides the evaluation of the platform against requirements, gaps and pedagogical objectives, comparing the work done to the work outlined in D2.1 and D2.2 also finalizing activity 17 (Refinement and final evaluation of the operationalized augMENTOR architecture) of the alignment strategy presented on D2.2. Chapter 6 discusses advanced methodologies and illustrates use-case scenarios (covering the work done T5.5). Finally, chapter 7 concludes with a summary of achievements and future plans.

1.2 Relevance to other augMENTOR deliverables

D5.2 integrates with other project outputs. D5.1 provides KGs, and D3.3 defines the learner model for profiling and recommendations. D3.2 introduces the final Technology-augmented Educational Scenarios and e-Activities (TESA) micro-level of the augMENTOR framework, while D4.2 and D4.3 cover creative pedagogy, ensuring platform integration and aligning WP3, WP4, and WP5. These inform indicator selection and data-driven metrics in D3.3 and WP5, forming the pedagogical basis for learner modeling and policy recommendations. D5.2 also incorporates insights from WP6 pilot validations (to be presented in D6.2). Furthermore, D2.1 and D2.2 define pilot and user requirements, evaluated in Chapter 5. Thus, D5.2 marks a project milestone, transforming specifications into a functional, evaluated platform demonstrating AI-boosted learning in real pilots.

[1] https://augmentor-app.eu-dev.novelcore.org/

2 AI-boosted augMENTOR platform: Overview and architecture

2.1 Platform overview

The augMENTOR platform is an AI-powered educational system that provides intelligent recommendations, feedback, and knowledge discovery through advanced machine learning and knowledge graph technologies. This ecosystem is designed to deliver personalized educational experiences by integrating with Moodle and TryHackMe, which were selected based on pilot requirements. Pilots #1, #2, and #3 use Moodle for online courses, while KTU chose TryHackMe for its virtual machine capabilities. Given Moodle is widely used as a pedagogical platform, its selection also makes the augMENTOR platform more accessible and easier to be adopted by a wide range of educational organizations in the future. The AI-based components designed and delivered through the work done in WP5 tasks include:

- **Explainable Guidelines (Explanation Generator and Reporting Engine):** Generates insights and explainable guidelines that help learners, educators, professionals responsible for instructional design with the teaching and learning process and enables course refinement according to learners' needs.
- **Personalized Recommendations (Recommendation Engine):** Provides personalized recommendations for learners based on course data and the learner model deployed.
- **Knowledge Discovery (ML pipelines for knowledge discovery):** Enables knowledge discovery, particularly on course and learners' progress, through semantic graphs and advanced analytics. It should be noted that this is not presented as a separate microservice, as it is an integral part of the above pipelines.
- **Policy Support (Educational Policy Recommendations System):** Supports policy-making and decision support for education and training stakeholders.
- **Secure and scalable deployment (Infrastructure layer):** Ensures secure, scalable, and interoperable deployment across heterogeneous pilot environments.

2.2 Platform architecture

2.2.1 Architecture layers

The augMENTOR platform adopts a microservices architecture and organizes the aforementioned components into structured logical layers, each responsible for distinct functionalities. More specifically:

- **Frontend layer**: A React-based user interface that provides dashboards for learners, educators and policy makers. This layer also includes external integration with educational platforms, enabling learners to view augMENTOR recommendations through the LMS (Moodle only) features on top of the augMENTOR user interface.

- **API (Application Programming Interface) gateway layer**: A FastAPI application acting as the main server, handling Hypertext Transfer Protocol (HTTP) requests, authentication, orchestration of AI pipelines and business logic. A PostgreSQL Handler executes stored procedures for secure and efficient database operations.
- **AI and ML services layer**: Comprises of the Inference Server for AI model serving (Large Language Models (LLMs) for reasoning, feedback and similarity), the Knowledge Graph API (based on the ontologies presented in D5.1) for semantic queries and continuous data updating, and the augMENTOR Profiles service, which operationalises the learner model defined in D3.3 for personalisation.
- **Data and storage layer**: PostgreSQL stores transactional data (interactions and recommendations), while Neo4j manages the KG. The services communicate primarily via HTTP-based API calls. Additionally, a lightweight message bus can be leveraged for asynchronous event propagation.
- **Infrastructure layer**: Provides authentication and identity management (ZITADEL), observability (OpenTelemetry, Prometheus, Grafana), and container orchestration through Docker and Kubernetes.

This layered design ensures modularity, scalability and interoperability, aligning with augMENTOR's objectives of explainability and adaptability.

2.2.2 Architectural evolution: From reference to technical architecture

The transition from the Reference Architecture (RA) (Figure 5. in D2.2) to the deployed Technical Architecture (TA) translates the abstract components specified in earlier phases (D2.2) into a concrete, deployable blueprint. The TA reflects several engineering decisions that refine the initial RA, optimizing the design for deployment and continued operation. The final TA is presented in Figure 1. The TA does not include major deviations from the RA; however, a few key adjustments were made to optimize the design, as detailed below.

1. API consolidation and service realization

The initial RA's abstract APIs and AI components were consolidated and materialized into high-performance microservices:

- **Backend Data Access:** The conceptual backend raw-data API is specifically implemented as the PostgreSQL Handler microservice running on Port 8080. This handler provides the necessary Data Access Layer (DAL) for structured learner and course metadata stored in the PostgreSQL Database.
- **AI/KG Orchestration:** The two distinct services in the RA, the KG API and the Inference Server API, are consolidated into the functional core of the system: the FastAPI Application layer. This FastAPI Application (Port 8000) is responsible for orchestrating complex tasks, such as querying the Neo4j Knowledge Graph and managing the outputs from the augMENTOR AI models (Learner Profiling, Inference Server).

2. Communication and data flow optimization

A deliberate architectural decision was made to streamline the data pipeline and prioritize performance:

- **Direct Third-Party Integration:** In the RA, external data providers were conceptualized as "Third-party services". In the actual TA, the Third party providers (Moodle, TryHackMe) are integrated to send data straight to the Knowledge Graph API via the FastAPI layer. This direct path optimizes data ingestion and feature extraction into the Neo4j KG.

3. Formalized infrastructure and security layers

The TA formalizes the underlying infrastructure components essential for a production-ready environment:

- **API Gateway Layer:** A dedicated API gateway layer is introduced to serve as the central, secure public entry point for the augMENTOR platform web interface.
- **Explicit Technologies:** The final TA specifies the exact technologies for the horizontal layers, including ZITADEL for authentication, and the Docker/Kubernetes stack for the container platform.
- **Observability Stack:** The generic RA requirement for monitoring is implemented using the industry-standard OTEL/Prometheus/Grafana stack for detailed observability metrics and logging.

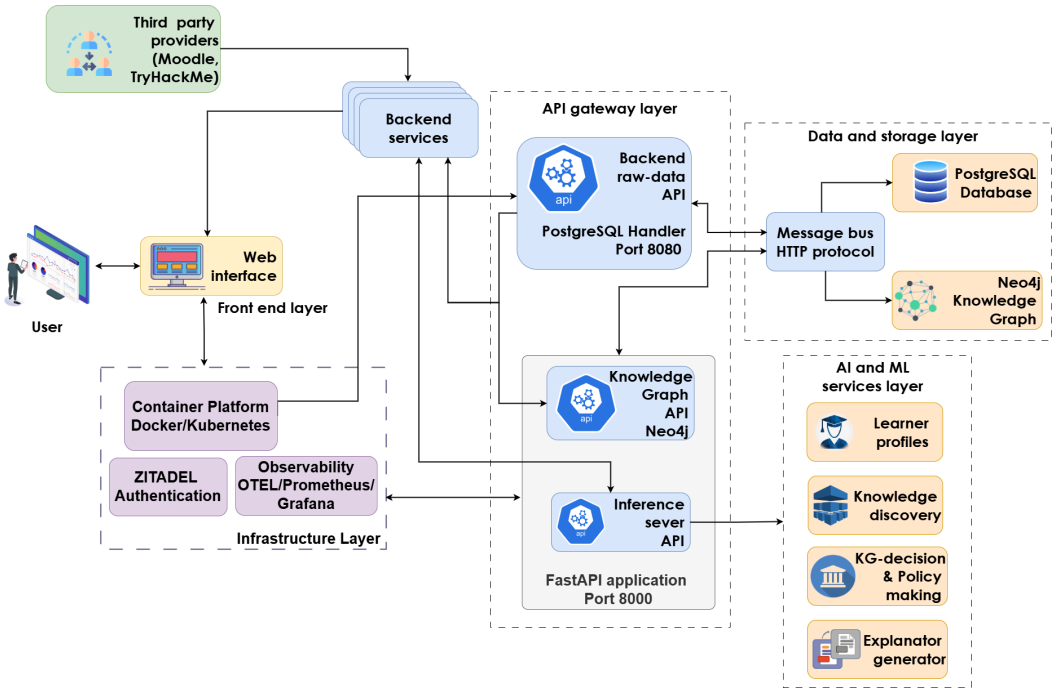

Figure 1. *High-level architecture of the augMENTOR platform, showing layered microservices design*

Finally, to address a reviewer's query about resource over-specification presented in Table 13 in D2.2, it should be noted that this was an error. The final Technical Architecture (TA) implemented optimized, low-footprint resource specifications for the deployment of the augMENTOR platform, mandating a dual-core processor with ≥4GB RAM and ≥500MB space for optimal cost-efficiency.

2.2.3 Data flow architecture

The flow of data across components, based on the TA presented above, illustrates the platform's mechanism for handling user queries securely and transparently by transitioning through the integrated layers. When a learner or educator submits a query:

- the request is authenticated
- once validated, the API server orchestrates knowledge retrieval by converting the query into Cypher syntax and submitting it to the KG
- the AI/ML layer then addresses the request with KG context
- the inference server applies AI-based reasoning to generate personalised feedback
- results are stored through the PostgreSQL handler for monitoring and analysis
- the processed response is returned to the user through the web interface.

Figure 2 depicts the sequential steps from user input to enriched recommendation delivery.

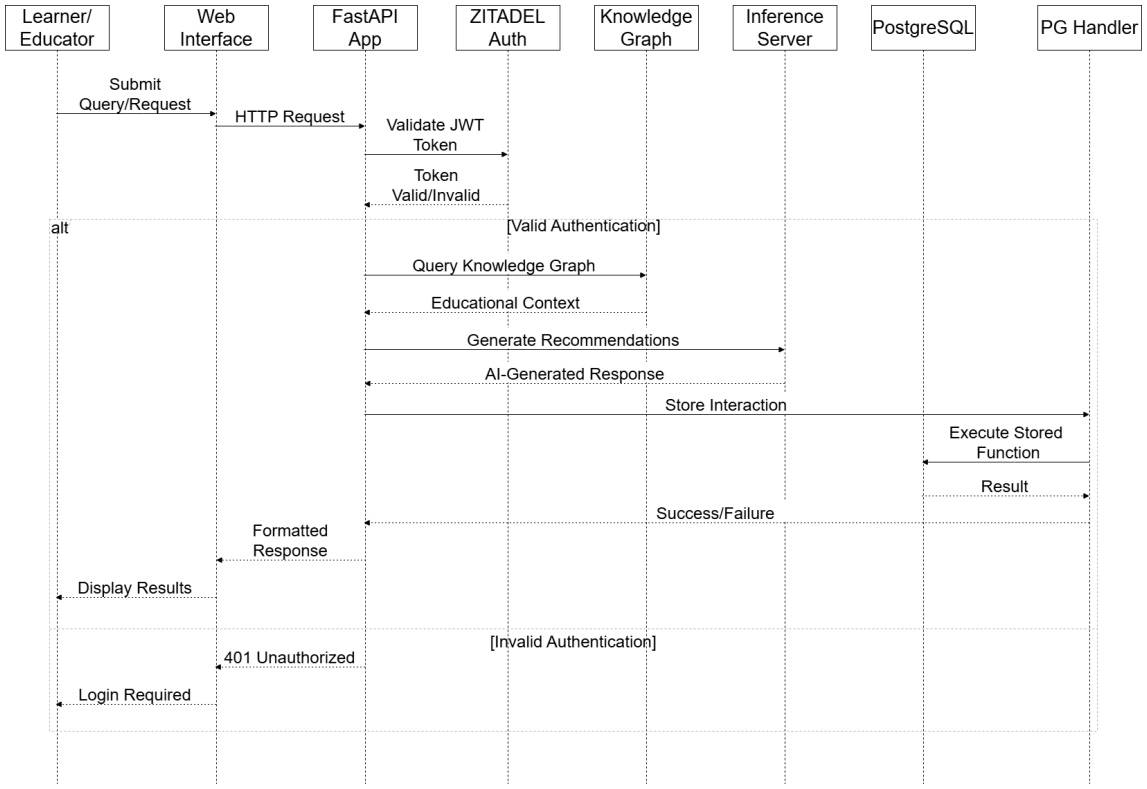

Figure 2. *Data Flow Architecture of the augMENTOR platform*

2.3 Updated knowledge graph

The updated augMENTOR KG builds upon the foundations established in D5.1 and extends its scope to incorporate both richer activity data and the learner profiles defined in D3.3. It serves as the semantic backbone of the platform, enabling integration of heterogeneous data sources, supporting explainable recommendations, and providing educators and policy makers with interpretable insights into learning processes.

At its core, the KG unifies ontologies from the supported learning platforms. The Moodle ontology models learners, teachers, courses, modules, activities (forums, quizzes, SCORM objects and assignments) and resources, with relationships that capture registration, teaching and participation. Properties associated with these entities record engagement indicators such as grades, number of attempts and time on task.

The TryHackMe ontology, as presented in D5.1, represents rooms, tasks, questions, modules and learning paths, structured through hierarchical relationships that describe learner progress. Properties here include difficulty levels, scores and completion times. This ontology did not need to be updated. While the TryHackMe ontology did not require any extension, the Moodle ontology was significantly extended.

The most significant extension is the integration of learner profiles developed in D3.3. Learner entities are now enriched with profile attributes covering cognitive, affective and transversal skills. These are linked via *BELONGS* relationships, operationalising the augMENTOR learner model within the KG. In addition, activity nodes (such as quiz or forum interactions) are annotated with indicators for creativity, collaboration, communication and critical thinking, ensuring that the 21st-century skills framework is embedded directly into the graph.

The KG has also been enhanced with expanded metadata. Detailed interaction data, including clicks, submissions and time spent, are now captured, along with higher-level derived metrics such as engagement and struggle scores for quizzes and assignments. In addition, the KG now records activity-level statistics, such as completion rates, number of attempts, time distributions and action sequences, enabling deeper analysis of how learners interact with different types of tasks. Complementing these indicators, the KG includes a learner characterisation summary, grouping users into categories such as *"One-Shot Completer," "Consistent Multi-Session Worker"* or *"Persistent Struggler."* These abstractions provide educators with an interpretable overview of learning tendencies at a glance, while preserving access to the detailed activity trace for deeper analysis.

All metadata and derived indicators are stored alongside semantic annotations aligned with external vocabularies, ensuring interoperability and reuse across systems. Through these extensions, the updated KG fulfils a dual role. First, it functions as a semantic integration mechanism, bringing together data from multiple platforms, profiles and activity types into a single coherent structure. Second, it operates as an explainability engine, linking recommendations and analytics to the underlying evidence so that both learners and educators can understand why particular outputs are generated.

2.4 Scalability and use with additional learning management systems.

The augMENTOR platform's architectural foundation is deliberately designed for scalability and long-term sustainability, underpinned by an adaptable ontology model depicted in Figure 3. This design ensures that the system is not tethered to a single LMS. The conceptual model is driven by a high-level, domain-agnostic ontology that represents core educational relationships: Course, Learner, Activity, and augMENTOR Profile.

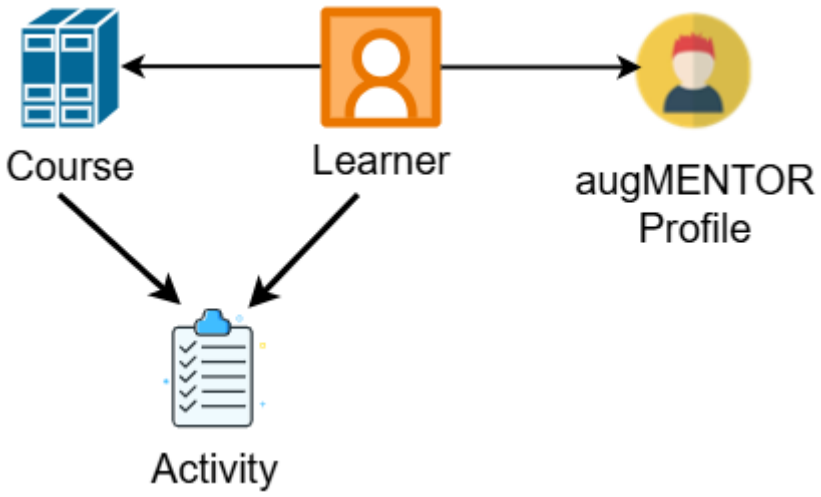

Figure 3. Domain-agnostic ontology

To support additional educational platforms in the future, this core model is specialized to allow integration of modified ontologies generated based on new LMS features.

The crucial distinction is that data collected from each LMS is transformed into properties that enrich the nodes and define the relationships of the high-level ontology, accommodating unique activity types and log file features while maintaining a unified semantic structure. This flexible structure is key to both the platform's interoperability and its future sustainability, allowing for the relatively straightforward integration of new educational scenarios or external systems without requiring a complete architectural redesign.

3 AI-boosted platform pipelines and models

This chapter reports on the fully interoperable deployment of the core models and mechanisms of the augMENTOR platform developed under Tasks T5.2, T5.3, and T5.4. The AI/ML algorithms implemented are also presented in this section; it should be noted that in total 6 algorithms are used thus covering kpi 1 (# of customized/individual AI/ML algorithms >4). More specifically, the algorithms are: 1. Gaussian Mixture Models and 2. Random Forest (Learner Profiling), 3. Uniform Manifold Approximation and Projection (dimensionality reduction), 4. Local Interpretable Model-agnostic Explanations (core transparency and explainability), 5. Recommendation Generation Model (generating recommendations) and 6. Natural Language Query to Cypher Conversion (feedback generation engine). Finally the chapter presents the microservices deliver (also in relation to kpi 15 (# of micro-services developed >5): 1. Semantic Data Integration & Resource Mapping (hosting the KG/Data APIs), 2. Explanation Generator, 3. Reporting Engine, 4. Decision Support and Policy Recommendation, 5. Personalized Learning Profiles Design, 6. Feature Extractor and ML-Based Pattern Discovery.

3.1 Learner profiling pipeline

The learner profiling pipeline addresses two (2) fundamental challenges: (i) grouping learners into clusters based on information about the learner's knowledge and skills state, cognitive characteristics, actions and practices as well as their behaviour and their competencies; (ii) providing explainability about why a learner is assigned to a particular profile. In doing so, it operationalizes the augMENTOR LM defined in D3.3, transforming theoretical constructs into actionable, data-driven learner profiles.

3.1.1 Proposed methodology and feature rationale

The development of the learner profiles follows a systematic hybrid methodology [1] that combines unsupervised clustering with supervised classification [2] and explainability modules. The scope of this methodology is to create a module that delivers profiles that are domain-agnostic and generalizable across diverse contexts thus also supporting the expandability and the scalability of the proposed solution.

The feature selection prioritizes reliable learner modeling by adopting a hybrid approach to directly represent cognitive, affective, and skills-based constructs. This feature set is explicitly aligned with the augMENTOR reference learner model (D3.3):

- **Engagement metrics** (derived from Moodle logfiles) correspond to the affective domain in the reference model. It focuses on observable behaviors related to learner motivation and affective state. The data quantifies learner activity (based on the methodology proposed by Cristea et al. [3]) into three core metrics: Autonomy, Competence, and Relatedness (see Annex A). The output is converted using a

binning strategy into categorical bins (Low, Medium, High, Very High) to ensure interpretability for non-technical stakeholders and simplify clustering analysis.

- **Cognitive domain data** (via questionnaires and performance indicators) align with the cognitive domain factors outlined in the reference model.
- **Learner performance related to the 4Cs** (Critical Thinking, Communication, Collaboration, and Creativity) is mapped directly to the transversal skills dimension in the reference model. This models the learner's competencies based on assessment rubrics (assessment details for the 4Cs are documented in D4.3).

The methodology, driven by the pedagogical requirement (D3.3), adheres to the LM's constraints: profiles rely exclusively on traditional desktop-based learning environment data, explicitly prohibiting all sensor and wearable data. This prioritizes automated data mining while avoiding intrusive sensors that disrupt learning.

3.1.2 Profile generation and assignment

The profile generation process is divided into two sequential parts:

a) Unsupervised clustering - Developing the profiles

The initial profiles are generated by a sequence of processing steps on the pre-processed data, gathered from questionnaires, learner performance data and engagement metrics:

1. **Data pre-processing and scaling:** The raw data undergoes pre-processing, including checks for non-valid values and imputation for handling Not A Number (NaN) values. A scaler application (normalization) is then applied.
2. **Dimensionality reduction:** The scaled learner data undergoes dimensionality reduction (UMAP - Uniform Manifold Approximation and Projection) to reduce variance.
3. **Clustering:** Finally, the dimensionally reduced data is used by the Gaussian Mixture Models (GMM) algorithm [4] for "grouping" the learners into groups/clusters. This algorithm is selected due to its consistently superior performance among various tested methods. The output is the set of generated augMENTOR profiles (clusters) for each pilot.

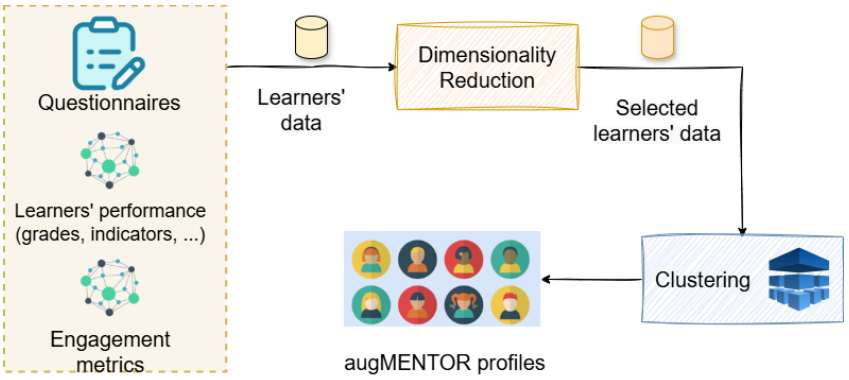

Figure 4. *Generation of augMENTOR profiles*

b) Supervised classification and explainability

The architectural decision to train a second, supervised classifier is motivated by the mandatory requirement for local explainability in a trusted AI environment.

- **Need for Explainability:** The initial unsupervised model (GMM) successfully identifies the optimal learner clusters. However, clustering models inherently cannot provide local explanations for why an individual new learner is assigned to a specific group.
- **Classifier Training:** To solve this critical gap, a labeled dataset is created (where the clusters serve as labels) and used to train a supervised Random Forest (RF) classifier [5].
- **LIME Integration:** This RF model is then integrated with the Local Interpretable Model-agnostic Explanations (LIME) module, which produces a local explanation that is subsequently passed through a Large Language Model (LLM) to generate a human-readable justification for assignments, offering the interpretability that purely clustering models cannot inherently provide.

The profile assignment mechanism ensures the output is trustworthy, predictable, and immediately actionable for educators, satisfying the project's mandatory explainability requirement.

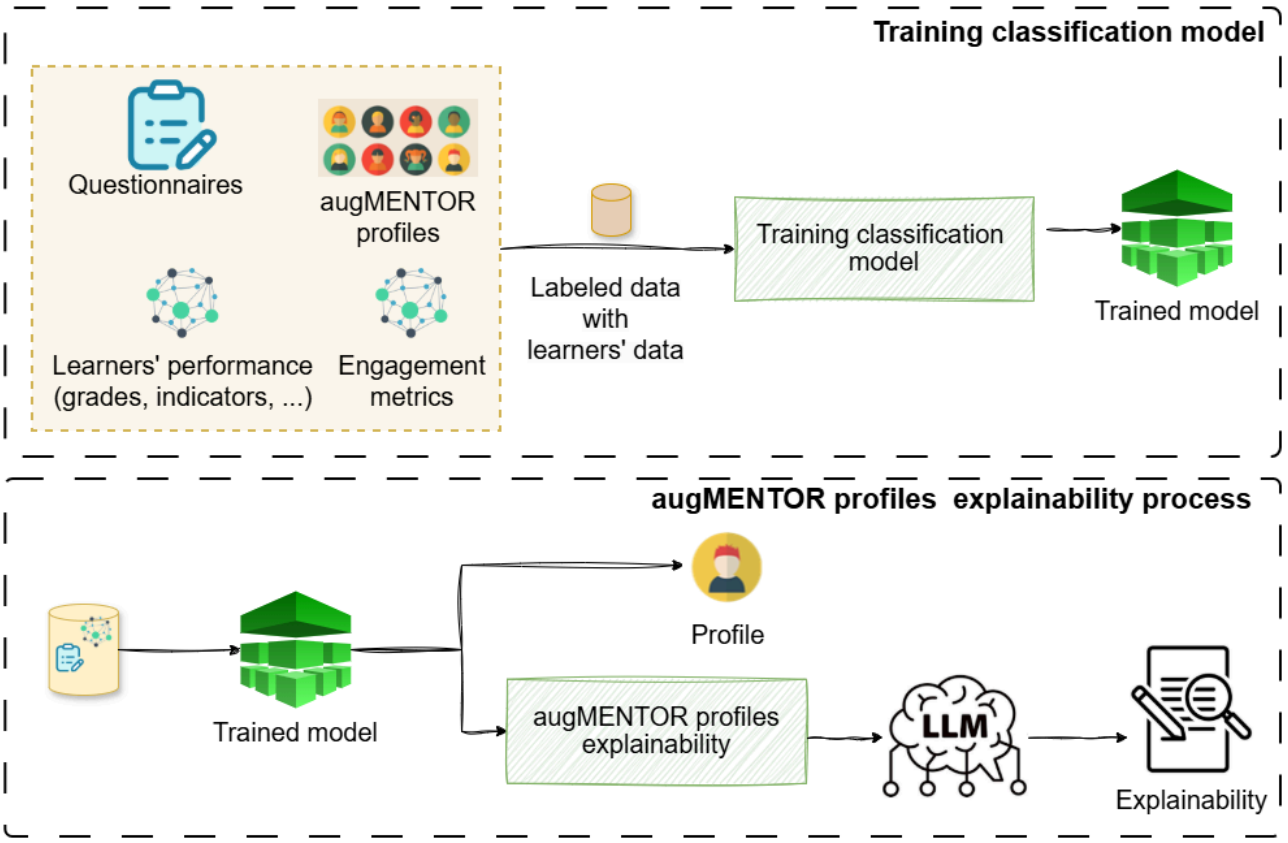

Figure 5. *Learner assignment to profiles*

3.1.3 Example and profile details

The augMENTOR platform integrates the final output, offering educators immediate, explainable insights. It provides local explainability for individual profile assignments, detailing key influencing features. This gives educators actionable insight into student strengths and intervention areas. In Figure 6 below we present an example. For "IASIS_A" (High-Autonomy, High-Competence), the visualization shows the top 4 influencing features. Positive influences were high grades and autonomy. Negative influences were scores in relatedness and creativity. This informs educators of student strengths (self-regulation/performance) and areas for intervention (social/creative collaboration).

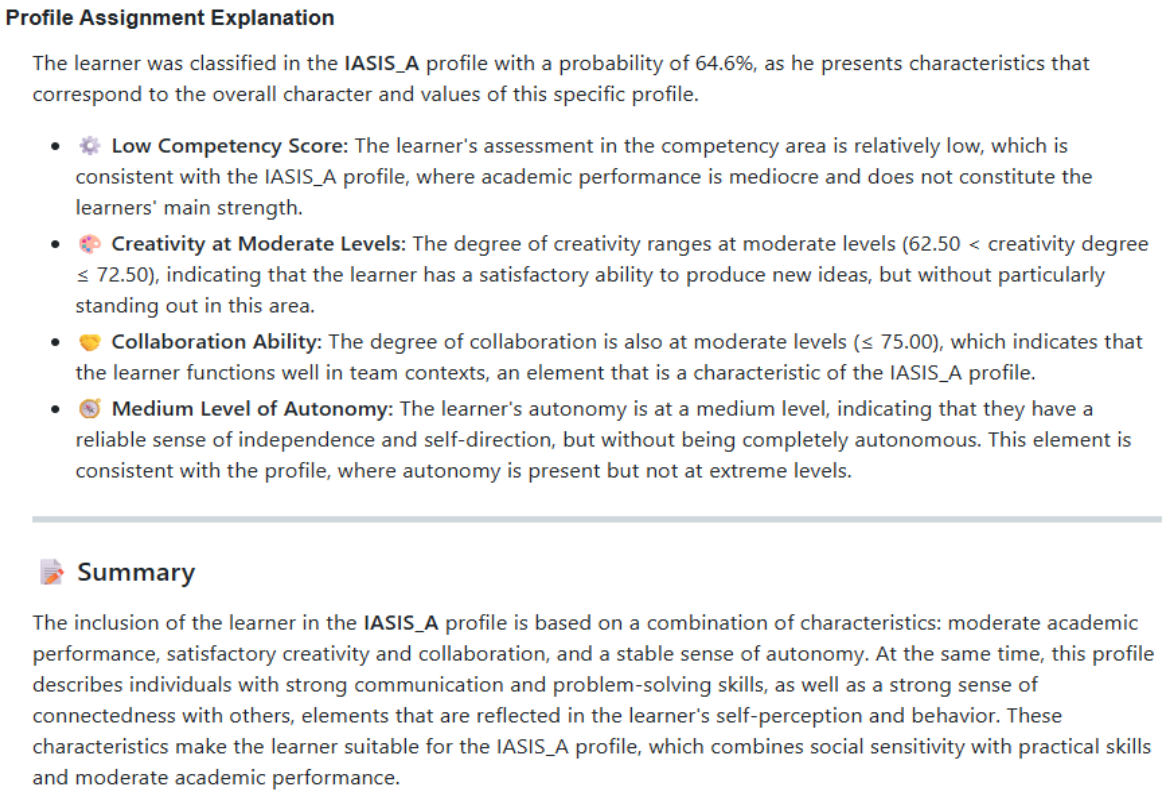

Figure 6. *Learner profile assignment with LIME-based local explainability.*

3.2 Explanation generator and reporting engine pipeline

The explanation generator and reporting engine pipeline is responsible for generating both immediate contextual feedback and structured quality evaluation reports for all AI-driven responses [6]. This core component enhances platform reliability, transparency, and user trust. This pipeline is specifically architected to address the necessity of merging semantic representations with the LLM [7] for pedagogical soundness, a critical objective raised in prior project reviews.

3.2.1 Feedback generation engine pipeline

This pipeline is responsible for delivering to users the feedback generated following a query. The process implements a sophisticated multi-stage validation and knowledge retrieval workflow designed to ensure content quality, appropriateness, and educational value.

When users submit queries to the platform the pipeline is initiated and the feedback generator module, which serves as the primary entry point, captures essential user context and generates a personalized response. It should be noted that all user queries undergo mandatory content screening through the offensive content identification module. Queries flagged as offensive immediately terminate the processing pipeline, and users receive explanatory feedback regarding the content policy violation.

The system implements role-specific processing, particularly for learners queries pass through a learner question validator and transformer module, which acts as an additional validation layer to ensure queries comply with educational guidelines by preventing requests for peer information or inappropriate content sharing. Educator queries proceed directly to knowledge retrieval.

Validated queries are processed by the query transformer to Cypher module, which converts natural language into Cypher query syntax for KG interaction. The generated Cypher queries execute against the KG database to retrieve relevant educational data and contextual information. Concurrently, the instruction retriever module accesses the instructional database to gather predefined educational guidelines, procedural instructions, and contextual information relevant to the user's query domain.

The context-based feedback generator synthesizes all retrieved information (KG data, instructions, and user context) to generate a comprehensive, educationally appropriate response tailored to the user's specific requirements.

3.2.2 Response evaluation integration

The augMENTOR platform includes an automated response evaluation module designed to assess the quality of AI-generated feedback. This module functions as a constant monitoring mechanism to be delivered to the platform administrators aiming to enhance the overall reliability in the platform's feedback outputs.

When activated, each response returned by the system is accompanied by an evaluation report that analyses and scores its quality according to a set of predefined metrics:

- **Groundedness:** Measures whether the answer is supported by evidence from the KG or other verified sources.
- **Context Relevance:** Assesses the degree to which the answer addresses the learner's query and situational context.
- **Correctness:** Ensures factual and technical/pedagogical accuracy of the generated content.
- **Completeness:** Evaluates the comprehensive coverage and inclusion of all key information elements expected in a response.

- **Answer Relevancy/Faithfulness:** Assesses alignment with the user's intent and consistency with the source materials and educational goals.

Each of these individual metrics is scored using a numerical rating scale (1–100). After evaluation, a total quality score is produced, as the mean score of all individual metrics accompanied by an explanatory breakdown of the individual metrics.
Finally, we also point out that a hybrid approach, which combines LLM evaluation, a Model Context Protocol (MCP) server with expert human oversight and possibly the use of reference datasets or legal ontologies to anchor factual accuracy, is the best feasible option.

3.3 Recommendation generation pipeline

The recommendation processing pipeline [8] extends the initial feedback loop by incorporating analytical and learner profiling data to provide personalized educational recommendations and actionable policy insights. This task is a realization of the KG based decision and policy making component. The core workflow relies on a multi-stage processing architecture designed to ensure recommendations are comprehensive [9], contextually appropriate, and pedagogically sound.
The process begins with the user query and contextual parameters (username, role, language), which are processed by the feedback generator. The preliminary response from the feedback generator provides immediate contextual value and acts as a critical input for subsequent stages. The query and initial feedback are simultaneously forwarded to the instruction retriever and the receiver identification module. The instruction retriever accesses the instructional database to gather relevant educational guidelines (following the TESA framework) and domain-specific content, enriching the recommendation context. The receiver identification module analyzes the query and feedback to determine appropriate recipients, such as educators or learners. The recommendation generator module synthesizes all inputs, the original query, initial feedback, retrieved instructions, and identified recipients, to produce personalized recommendations. This synthesis ensures detailed guidance tailored to user roles and educational contexts.
The resulting recommendations provide detailed guidance tailored to user roles and educational contexts, enabling effective decision-making and educational improvement initiatives across the learning environment. An example query response including the resulting feedback, the generated guidance for course design for the educator and recommendations for the learner, is provided in Annex B.
Another key realization of the recommendation engine is the integrated educational policy recommendations system, which targets policy makers and institutional stakeholders to help improve educational processes and learner outcomes.

4 Educational policy recommendations system

The educational policy recommendations system extends augMENTOR's functionality, offering institutional guidance to policy makers as well as course providers, and administrators. This core component targets institutional stakeholders to help improve educational processes, outcomes, and learners' 21st century skills using evidence-based insights aligned with the TESA framework. The system generates structured policy recommendations by drawing upon learner profiles, performance analytics, and the TESA framework (including the 4Cs assessment).

4.1 Architecture and policy generation pipeline

The architecture is designed for reliability and ease of expansion to accommodate future project growth. The current deployment supports full 4Cs and knowledge assessment. Its modular design combines graph database retrieval with generative AI capabilities allowing easy extensibility for new institutions or skill assessment taxonomy modifications.

The system relies on the Neo4j database for learner data, the OpenAI API for the core AI service, and specialized Python libraries (neo4j, openai, json, ast) for connectivity, model access, and secure data handling. Robust error handling, including logging of database connection issues, OpenAI API rate limits, and missing configuration files, ensures high reliability. The policy recommendation pipeline comprises four interlinked stages that transform learner data into institutional insights:

1. **Data retrieval module:** Extracts learner performance data, course information, and profile metrics directly from the Neo4j database.
2. **AI-powered analysis:** Uses OpenAI's language models to combine raw performance data with pedagogical context drawn from augMENTOR profiles and TESA to provide recommendations that are grounded in personalized learning tendencies and characteristics identified during the Learner Profiling (T5.2). Critically, the system ensures recommendations are pedagogically sound by explicitly aligning insights with the TESA framework. All generated policies reference specific TESA phases and components.
3. **Policy generation orchestration:** This function merges retrieval and analysis outputs into a consistent structure, ensuring every recommendation set follows a standard logic and presentation.
4. **Output formatting:** Structures final recommendations into actionable policy documents (Output Formatting: Structures recommendations into actionable policy documents).

4.2 Output structure, pedagogical alignment and overall evaluation

Generated recommendations follow a precise, structured format designed to maximize clarity and actionability for institutional stakeholders. The TESA framework provides the pedagogical foundation for all outputs. This rigorous integration ensures that all generated policies reference specific TESA phases and components, guaranteeing they are evidence-based, pedagogically sound, and align with modern educational practices.
Each set of recommendations follows a five-part structure to guide decision-making:

1. **General feedback:** Provides an executive summary of findings and overall performance insights across all profiles.
2. **Discussion about learners' profiles:** Outlines the detailed traits and learning tendencies of each augMENTOR profile represented in the course.
3. **Performance insights:** Delivers data-driven analysis of profile-specific strengths, weaknesses, and behavioral trends.
4. **Policy recommendations for supporting learners:** Proposes targeted interventions, course-integrated strategies, and skill-development activities aligned with the TESA framework.
5. **Policy recommendations for supporting educators and course providers:** Offers guidance on teaching methods, resource adaptation, and institutional planning.

An example set of recommendations for one of the courses is presented in Annex C. This part of the platform was validated with 20 users in dedicated policy making events from the pilots as well as the cluster policy making event organised by augMENTOR and its sister projects in Brussels (also covering KPI#4: # of policy/ decision making evaluated >3). In total participants reviewed five (5) out of the six (6) available sets of recommendations. Overall, the feedback received, yielded an overwhelmingly positive validation, with a mean presentation quality rating of 4.45 out of 5.00 and the majority of users selecting the maximum score (5.00) as the mode and median response. This strong result is underpinned by the fact that nearly three-quarters (72.2%) of the participants (including academics, instructors and researchers) expressed a willingness to adopt the platform, which serves as a key indicator of product viability and perceived usefulness. Furthermore, the analysis confirmed the strategic value of the platform's outputs, with the recommendations targeted at educators and course providers being deemed the most useful section overall. A more detailed analysis of the outcomes is presented in Annex D.
Based on the feedback no interventions were made to the content generation. However, with regards to the user experience, it was decided at a later stage to slightly alter the 'Policy Recommendations' section and turn static sections to expandable ones to avoid long scrolling by the users. Furthermore, a pdf document is also available for users who wish to download the set of information and recommendations (available per course).

5 Evaluation and requirements fulfilment

The evaluation efforts undertaken here are in response to the reviewers' suggestions during the mid-term review and according to the alignment strategy item 17 (see Deliverable D2.2). In particular, the reviewers pointed out that "*the complete functionality of the augMENTOR architecture becomes available only at M33 which is too late for meaningful impact evaluation or revision*" and further requested further information regarding:

a) how the technical specifications met the pilots and users expectations (see Deliverable D2.1);
b) how augMENTOR delivers what was promised in the proposal in terms of the pedagogy and 21st century goals of the project, and is usable by the implementation partners;
c) how augMENTOR addresses the gaps identified in Literature Review (see Deliverable D2.1).

To address the points aforementioned, we carried out a mixed-methods evaluation triangulating quantitative and qualitative data collected from various sources:

- User satisfaction surveys were administered to the end-users (educators) in individual pilots to gauge their satisfaction with the degree with which the augMENTOR platform met their needs, specifically focusing on pedagogy and 21st century skills. Further, selected interviews took place with educators and pedagogy experts for additional insights;
- Semi-structured interviews and retrospective analysis with experts and project partners were used to assess technical readiness and veracity of the augMENTOR platform.

This evaluation does extend to the evaluation of technical aspects of augMENTOR. We present the evaluation results according to points (a), (b) and (c), as follows.

5.1 Technical specifications, pilots and users expectations

To map the platform features to requirements defined in D2.1 - Pilots definition and user requirements analysis, we revisited the user requirements and the current architecture of the augMENTOR platform with the partners from WP2 and WP5 following a focus group format.

The results of the evaluation carried out from May to July 2025 showed that all user requirements were partially met, but teacher-mediated, which is in alignment with the project proposal. At the moment of the evaluation, the pipeline underpins augMENTOR profiles-informed explainable recommendations, including recommendations for policy makers. However, interviewees highlighted that recommendations feel "a bit personalized, but a bit generic, with thin, sentence-level justifications". The focus-group and expert reviews corroborate these findings, indicating that augMENTOR is teacher-mediated,

usable, and progressing, with clear strengths in explainable, data-informed support, but gaps remain in pedagogy-aware recommendations and lack sufficient granularity in explanation of rationales. Similarly, reflection and engagement are supported through explainable recommendations and learning analytics. Privacy is strong (server-side pseudonymization) and multilingual support exists.
Overall, the evaluation indicates that the architecture has sufficient foundations at the moment this evaluation was carried out, while highlighting some gaps in pedagogy-aware recommendations and generated explanations. Implementation partners reported no documentation issues for the reference architecture. Annex E presents the outcome of the focus group in detail as well as the overview following the actions taken (see section 5.4).

5.2 Alignment with objectives regarding pedagogy, 21st century skills and usability

We conducted a User Satisfaction Survey (USS) consisting of twenty four (24) items rated from 1 (very dissatisfied) to 5 (very satisfied) with users (educators) (N=18) from the three pilots who used augMENTOR and focusing on how augMENTOR delivers in terms of pedagogy, 21st century skills, usability and usefulness. The results showed that the educators found the *learning analytics* are sufficiently informative (Mdn = 5; Q_1–Q_3 = 3–5). The educators perceived that the augMENTOR platform helps them monitor, and provided useful recommendations, for students' *engagement* (2-item composite; Mdn = 4.5; Q_1–Q_3 = 3.125–5) and *motivation* (2-item composite; Mdn = 3; Q_1–Q_3 = 3–4.875). The educators also reported that augMENTOR helps them reflect on their teaching and provides data driven course design recommendations (2-item composite; Mdn = 4; Q_1–Q_3 = 2.625–4.75).

Regarding the augMENTOR feedback and recommendations, educators stated that it encouraged *critical thinking* and *problem solving* among their students (2-item composite; Mdn = 4.25; Q_1–Q_3 = 3.125 -- 4.875). They also pointed out that their students perceived the recommendations and feedback from augMENTOR as *useful* and that these recommendations and feedback are *pedagogically sound* and *meets the individual learner's needs* (4-item composite; Mdn = 4; Q_1–Q_3 = 3.25 -- 5). The educators reported that the augMENTOR platform helps them improve their feedback (Mdn = 5; Q_1–Q_3 = 3–5), with most teachers indicating they would relay the platform's recommendations largely unchanged to students (Mdn = 4; Q_1–Q_3 = 3–5). However, in a control question asking the opposite, i.e, if they would 'read, adapt, and use when passing it on to students', the teachers rated this item equally likely (Mdn = 4; Q_1–Q_3 = 3–5). Finally, the teachers were more likely to recommend augMENTOR to other educators (Mdn = 5; Q_1–Q_3 = 3.25 -- 5).
In addition, we interviewed educators (carried out from June to July 2025) from the three pilots to get additional insights. The educators perceive augMENTOR as delivering

data-informed recommendations, but often generic and thin on visible justifications ['*It's a bit personalized, but a bit generic*'].
They stress the need for sentence-level evidence and clearer "why this, now" traces behind each suggestion ['*We said that we're going to have these explanations in each sentence component… This is an open point*.'].
In practice, recommendations are produced by an pretrained off-the-shelf LLM based on the learner's history, not from a pedagogy-specialized model, hence a risk of losing the theoretical rationale in the final recommendation. The experts indicated sentiment that the platform's features are partial but progressing. They state that the platform can frame insights around the 4Cs and learner progress, and it supports personalized recommendations; however, it doesn't differentiate learning designs (e.g., inquiry/collaboration), lacks fine grained tutor/course-design guidance ['*have to gather and include more data to enrich the ontology…recommendations to be more personalized… this is something that they're working on*']. The experts prescribe making recommendations that are history-aware, pedagogy-aware, and implement the learner model end-to-end so profiles and indicators actually shape the recommender—while surfacing transparent, evidence-linked explanations to meet educators' expectations for actionable, trustworthy feedback ['*the learner model… it's crucial… If we implement the learner model, then everything is there… when you make an inference, you need to take the learner model into account as a whole rather than looking at one indicator each*'].
Continued work on the augMENTOR platform since the interview have taken the educators suggestions into account and made significant updates. Please follow Annex E for further information.
Regarding the needs of implementation partners, no issues or concerns in their implementation phase and therefore, we deduce that the technical documentation of the reference architecture is complete and clear.

5.3 Alignment with the gaps identified in D2.1

Technological adoption challenges. The learner model, which is a part of the augMENTOR architecture, is explicitly teacher-mediated and intends to generate explainable and interpretable recommendations. The augMENTOR architecture makes use of data from the KG, profiles and learner model (ongoing), to create explanations that build trust and, in turn, foster adoption. The augMENTOR platform emphasises heterogeneity across pilots (different pedagogies, tools, data, language), which reflects the noble intent, but the current pedagogy-specific fit required further work. Finally, the domain-agnostic nature of augMENTOR aims to address technological adoption challenges offering generic solutions for common issues.

Discrepancies in technological literacy and 21st century skills.
The integration of digital, and in particular, "intelligent" technologies in the classroom potentially pose the threat of widening the digital literacy divide - that is, although stakeholders have access to such technologies, they don't necessarily acquire the necessary skills and competencies to understand how they work or to use them appropriately. To address this gap, augMENTOR aims to deliver AI-informed *explainable* recommendations and feedback to stakeholders (primarily educators and learners) to support their practice while prioritizing transparency while also offering training materials.

Personalised learning, data privacy, and protection.
The augMENTOR platform commits to protecting learners privacy through privacy-by-design, processing/storing only pseudonymized data server-side. No local client is being implemented. Recommendations are personalised through pseudonymized learner identifiers that the teacher has access to and all communication flows through the teacher minimising privacy leaks.

5.4 Updates and refinements based on findings

The project team has taken into account all comments coming from this preliminary evaluation aiming to address comments and weak points. To improve the system, three major interventions took place:

a) Inclusion of the learner profiles in the process of generating recommendations
b) Update and enrichment of the KG (expanded metadata, activity-level statistics and learner characterisation summary - see section 2.3)
c) The integration of the entire TESA framework as a guide (final version presented in D3.2, delivered in June 2025), extending the original integration of the 21st century skills assessment.

These updates enabled the team to successfully integrate pedagogical principles with advanced AI capabilities and meet both functional and operational needs identified by end-users. The platform's functional requirements are fulfilled through its robust AI-driven architecture. Adaptive learning and skill development are supported by the Learner Profiling pipeline, which operationalizes the augMENTOR Learner Model across cognitive, affective, and transversal skill domains, providing continuous progress monitoring and competency-level analytics based on the 4Cs framework. Inclusivity and accessibility are maintained through privacy-by-design principles with server-side data pseudonymization and multilingual support. The Explanation Generator and Reporting Engine deliver personalized feedback by transforming learning analytics into interpretable insights grounded in course data, learner profiles, and the TESA framework. Engagement monitoring leverages metrics from log files and user interactions, while continuous improvement and reflective teaching are enabled through the platform's query-driven

architecture, allowing educators and learners to receive timely, explainable feedback and actionable recommendations throughout course progression.
Operational requirements are equally well-addressed through dedicated pipelines and pedagogical integration. The platform enhances feedback and inquiry-based learning by providing actionable insights structured according to TESA principles. Personalized learning pathways are enabled through profile-informed guidance allowing course adjustments at class and individual levels. Data-driven course design is fundamental, with all recommendations generated from actual implementation data captured by the updated KG. Reflective learning is supported through dual-loop mechanisms combining learner-initiated queries with teacher-mediated guidance, while TESA embeds problem-based activities for real-world application. Engagement challenges are addressed through personalized feedback and targeted recommendations based on comprehensive learner data. Pedagogical support is delivered through AI-boosted pipelines that transform queries into evidence-based guidance while maintaining strict human-in-the-loop protocols for final pedagogical decisions. Annex E presents the actions taken in detail along with the outcomes of the focus group.

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6 Innovative work methodologies: Education and training methodologies for the augMENTOR solution

This chapter details the development of innovative work methodologies (Task 5.5), a key output from integrating and validating the AI-boosted augMENTOR platform and its educational framework. Our work leverages feedback from four pilot implementations (WP6), to be reported in D6.2, which informs real-use scenarios but it also heavily relies on the work done by the pilots throughout the different stages of the project. It should be noted that although T5.5 began in M25, partners have tracked pilot work from WP2's requirements collection through course design in WP3 and WP4, to WP6's implementation, gathering insights throughout. This empirical evidence forms the basis for these methodologies, designed as a resource for relevant communities and organizations. This strategic output supports the evolving role of educators and leaders in the digital transition, addressing contemporary learning needs within augMENTOR.

6.1 Key outcomes from pilot experiences

The preliminary feedback obtained from the validation of the augMENTOR platform done in WP6 has offered valuable insights as to the use of the platform (reported in D6.2) but does not reveal significant variations to the use of the platform. Based on pilots' feedback, the key outcomes derived are the following:

A. Secondary education students support: Secondary education teachers have reported that their students, particularly those with limited literacy, digital skills, or disabilities, and those in non-English speaking settings (like Serbia), required extensive support from teachers. This support often involved the teacher reading feedback aloud and providing continuous, step-by-step guidance because the students struggled to read and understand the assignments.

B. Retrospective use vs formative assessment: Even though the retrospective use of the platform is valuable to upgrade and refine future courses, there is still a prominent need from educators to use the platform while a course is rolled out to give them the capacity to shape teaching and learning dynamically. A system that operates continuously throughout the course providing weekly or biweekly updates on learner progress and competency growth, transforms the tool to "living pedagogical companion". Such integration would allow educators to identify learning gaps early and intervene promptly, while students would benefit from ongoing, formative guidance.

In addition to these pilot implementation these outcomes, the team also outlined some more general outcomes based on the observation of pilots' work during the preparation period:

1. **Professional training is necessary:** The shift to AI-augmented teaching necessitates dedicated training for educators on the platform's functionality and the underlying theory, as platform adoption and effective implementation depend heavily on teacher competence.
2. **AI-Driven intervention requires human validation:** Pilot feedback confirmed that the AI's most valuable function is providing feedback (e.g., 4Cs scores and profile data) to the educator and recommendations for learners, however recommendations' review by the educator is vital to ensure that the final recommendation is pedagogically sound and contextually appropriate before reaching the learner.
3. **Pedagogical shift is essential:** The pilots demonstrated a need to shift from passive content delivery toward active, collaborative, and reflective learning models (the essence of TESA). The developed methodologies explicitly facilitate educators to make this shift, moving them from knowledge transmitters to facilitators of technology-augmented activities.
4. **Creative Pedagogy is a core element of contemporary pedagogies:** Student centred courses need to have creative pedagogy and the development of 21st century skills at their core. Meaningful skills' assessment through dedicated rubrics is highly effective while opportunities for formative assessment is essential to foster personalised learning and course optimization.
5. **Organizational clarity is key to adoption:** Successful platform deployment hinges on clearly defining the tutor and learner roles and managing the connection requirements, indicating that methodological training must cover organizational and administrative processes alongside pedagogical ones.

6.2 Scenarios of use

Below we present the most prominent scenarios of use.

1. Experienced Educator: Focus on deployment and management

Experienced educators, already familiar with technology-integrated pedagogies and the augMENTOR framework, will directly use the platform with designed courses (new or adapted from Moodle). This scenario highlights the platform's immediate utility for time-constrained in-service teachers (Pilots #2 and #3) who need actionable learner data, bypassing extensive framework training.

2. Beginner Educator: Focus on mastering the educational framework

This scenario targets users needing full pedagogical guidance to adopt technology-augmented pedagogies and deploy tools like augMENTOR. Educators should review TESA to design courses using creative pedagogy principles. TESA serves as the core training resource for complex pedagogical knowledge, aligning with pre-service teachers (Pilot #2) and those seeking professional development (Pilots #1, #3, #4) focused on instructional design competence.

3. Learner self-regulation focus

This scenario provides basic platform training for learners across all pilots, enabling them to query, receive feedback, and request recommendations. It supports strong self-assessment and regulation by highlighting performance gaps.

4. Policy makers and curriculum designer/school leader: Focus on strategic output

This scenario targets users who require aggregated data for strategic decision-making and overall course feedback. It addresses the augMENTOR platform's policy recommendations, fostering innovative methodologies and insights for organizations and communities. This covers policymakers, curriculum designers, and educational leaders across all pilots.

6.3 Innovative work methodologies

The innovative work methodologies is a core result of the project which addresses multiple target groups. It describes the whole rationale of the augMENTOR solution and presents how end users can navigate through it based on their needs (following the scenarios presented above). Thus, the team has made the decision to present them as a standalone consolidated document named "AugMENTOR Solution: Design, tools and guide to AI-augmented pedagogy[2]" that serves as the project's central methodological and strategic asset, detailing the transition to AI-augmented learning environments. In this section we focus on presenting the guide's structure and rationale.

6.3.1 Design rationale

The guide details the essential structural components for designing and implementing AI-augmented pedagogy. It begins with an overview of the augMENTOR solution and guides users through the platform's various sections. As stated in its introduction, the document serves as a crucial, centralized resource that condenses the project's complex work into a structured roadmap, facilitating the effective deployment and utilization of the augMENTOR solution.

Designed as a practical guide, it explains the functionality and application of all augMENTOR solution elements. Its content, design philosophy, technical requirements, and pedagogical recommendations are directly derived from official augMENTOR project deliverables, including academic theory, experimental findings, and project specifications. The document offers potential users guidance on developing activities and utilizing the augMENTOR platform, outlining the theoretical foundations of the augMENTOR solution and introducing its key functionalities to provide both prospective and current users with a clear understanding of its capabilities.

6.3.2 Structural components

The guide is organized sequentially, moving from the foundational theory to practical platform functions but it can also be used in a modular way. To better facilitate the readers,

[2] https://augmentor-project.eu/wp-content/uploads/2025/10/augMENTOR_User-Guide_v1.0.pdf

it includes a 'How to use' section following the scenarios and outcomes presented above, proposing different reading paths based on the readers needs. The main sections of the guide are as follows:

- **The augMENTOR solution:** Presenting the overall rationale of the augMENTOR solution and its two core dimensions; the pedagogical framework and the AI-boosted platform.
- **The augMENTOR pedagogical framework:** Breaking down the framework to the macro and micro-levels and their components.
- **Macro-level: Pedagogical Design Model with Emerging Technologies:** Outlining the conceptual design principles.
- **Micro level: Technology-augmented Educational Scenarios:** Operationalizing the design at the classroom level, guiding concrete phases and activity implementation.
- **Creative pedagogy and 21st century skills:** Introducing the creative pedagogy components, the 21st century skills and the tools for their assessment.
- **What does the augMENTOR platform offer?:** Outlining what the platform offers to each of the target groups.
- **The augMENTOR Workflow: From Moodle design to AI insights:** Offering instructions for designing and linking courses with the augMENTOR platform.
- **Navigating the augMENTOR platform:** Giving step-by-step instructions on platform use from each of the target groups.

7 Conclusions

7.1 Summary of achievements

This deliverable, D5.2, documents the successful technical integration and deployment of the AI-boosted augMENTOR platform, achieving Technology Readiness Level (TRL) 6 readiness. The Reference Architecture presented in D2.2 was turned into a robust, deployable Technical Architecture built on modular microservices. The deliverable presents all augMENTOR components, including learner profiling, explanation generator and reporting engine, recommendation generation, and policy generation.

Key achievements include the platform's successful integration of core AI systems, including the aforementioned components (also covering KPI #1 and KPI #15). The updated KG semantically unifies data from various LMSs, ensuring verifiable AI outputs. The TESA framework including the 4Cs along with the Learner profiles model are fully embedded, aligning AI services with student-centric pedagogical goals. The project also developed innovative work methodologies, providing a strategic guide for educators and policymakers on deploying AI-augmented pedagogy.

An additional piece of this deliverable is the initial validation of the educators and learners views of the platform that demonstrated successful fulfillment of the project's targets, evidenced by a user satisfaction survey, which confirmed high median scores for the platform's ability to provide data-driven, explainable recommendations that support educator reflection, engagement monitoring, and course design improvements. The policy recommendations part of the platform was also evaluated (covering KPI #4) demonstrating a very high positive validation.

7.2 Outlook and future plans

While the platform is fully deployed and interoperable, future activities could take place, moving the platform to higher TRLs. Focus could be placed on maximizing its pedagogical impact as well as its user experience transforming augMENTOR to a seamlessly integrated, deeply personalized, and accessible pedagogical companion. While future plans will be better outlined through a more thorough look at the validation outcomes (to be presented in D6.2), the insights communicated thus far indicate that the augMENTOR platform would benefit by upgrades focusing on a) deepening personalization and recommendation quality; b) enhancing accessibility and multimodality and c) improving analytics actionability.

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Annex A - Calculating engagement

Methodology for calculating ENGAGEMENT (*extended motivation*)

In the augMENTOR Learner Model, Engagement is one of the key metrics that represent learners. We use Cristea's et al. [3] approach for modeling Engagement. Cristea et al. [9] quantify engagement (and motivation) based on Self- Determination Theory (SDT), which we have adapted in the Learner Model (refer to D3.3). In short, Cristea et al.'s methodology provides a taxonomy of indicators/features (we adapted the indicators in the context of Moodle, in contrast to Mooc in the original methodology) which are categorised into the three main components of SDT, namely Autonomy, Competence, Relatedness (see Tables below). It should be noted that the features/indicators listed in the table may be used wholly or partially in the augMENTOR platform. They are not an exhaustive list or entirely mandatory. In the following, we provide further details on how a composite number [between 0-1] is calculated to quantify engagement.

- **ALL values of indicators/features from moodle in must be normalized** using *min-max (using max: as all values start at 0)* (by dividing the learner's score/value with the largest value in the list, i.e, the score/value of the highest achieving student)
- **The methodology allows flexibility to add and remove indicators based on the context and availability**

Engagement

To calculate Engagement, we use the formula:

***SDT*$_{Engagement\text{-}motivation}$** (Student, Time) **= (*Autonomy* + *Competence* + *Relatedness*)/3**

SDT$_{Engagement\text{-}motivation}$ $\in$ [0-1] for a **Student** within a certain **Time** is the average of three components of SDT, namely, **Autonomy, Competence, & Relatedness**. Each component is calculated as follows,

Autonomy

To calculate Autonomy, we use the formula:

$$Aut(s,w) = \frac{\sum_{A_i}\left(B_{A_i} \cdot \frac{X_{A_i}}{X_{A_i}^{\max}}\right)}{N}$$

Where:

- $\mathbf{A_i}$ is a feature where i∈[1,N] and N is the number of features in **A**. **'A'** represents the group of features used in the computation of *Autonomy* (see table below) for a particular learning scenario. Not all features in the Autonomy table below are mandatory or exhaustive.
- $\mathbf{X_{Ai}}$ is the value of A_i for the student (s) in the week (w), normalised by dividing it by X_{Ai}^{max}, which is the maximum value of A_i that week (w) for the whole class, i.e., the highest score for A_i among all students;
- $\mathbf{B_{Ai}}$ is the weight of feature A_i and should be a value between [0,1]; this weight allows different constructs to influence the result in a different way.
- Aut(s,w) ∈ [0,1] is normalised by dividing the result by the number of constructs (N) in **A**

Table 1. *Autonomy Features*

(All values are calculated in a timeframe W (for example W = one week)

Features (A_i)	Description	Mapping Moodle Ontology
A1	# Distinct Learning objects completed	# Learner (user_ID)-(number_of-submissions)-Scrom (id)
A2	# Quizzes undertaken	# Learner (user_ID) - (number of completed attempts) - Quiz (id)
A3	# Posts created in the forum	# Learner (user_ID) - (number_of_posts) - Forum (id)
A4	# Comments posted in the forum	# Learner (user_ID) - (number_of_discussion) - Forum (id)
A5	# Content resources accessed	# Learner (user_ID)-(*Count*)-Resource (id)
A8	Σ Time spent on learning contents	# Learner (user_ID)-(time)-Scrom (id)
A11	# Clicks (Scrom)	# Learner (user_ID)-(number_of_clicks)-Scrom (id)

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Competence

To calculate Competence (Calculates similarly*):

$$Com(s,w) = \frac{\sum_{C_i} \left(B_{C_i} \cdot \frac{X_{C_i}}{X_{C_i}^{\max}} \right)}{N}$$

Where:

- $\mathbf{C_i}$ is a feature where i∈[1,N] and N is the number of features in **C**. **'C'** represents the group of features used in the computation of *Competence* (see table below) for a particular learning scenario. Not all features in the Competence table below are mandatory or exhaustive.
- $\mathbf{X_{Ci}}$ is the value of C_i for the student (s) in the week (w), normalised by dividing it by $X_{C_i}^{\max}$, which is the maximum value of C_i that week (w) for the whole class, i.e., the highest score for C_i among all students;
- B_{Ci} is the weight of feature C_i and should be a value between [0,1]; this weight allows different constructs to influence the result in a different way.
- Com(s,w) ∈ [0,1] is normalised by dividing the result by the number of constructs (N) in **C**

Table 2. *Competence Features*

(All values are calculated in a timeframe W (for example, W = one week)

Features	Description	Mapping Moodle Ontology
C1	Σ Score on quizzes	Σ Learner (user_ID) - (grade) - Quiz (id)
C2/A4	# Comments posted in the forum	# Learner (user_ID) - (number_of_discussion) - Forum (id)
C3/A2	# Quizzes undertaken	# Learner (user_ID) - (attempts) - Quiz (id)
C4	Σ Time spent on quizzes	Σ Learner (user_ID)-(time)-Quiz (id)
C6	# Successfully completed quizzes	Σ Learner (user_ID) - (grade + submission) - Quiz (id)
C7	# Successfully completed quizzes were revisited	Σ Learner (user_ID) - (grade + submission + number of attempts) - Quiz (id)

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C8	# Assignments submitted	# Learner (user_ID)-(submitted)-Assign (id)
C9	Σ Time spent to submit the assignments	Σ Learner (user_ID)-(time)-Assign(id)
C11	# Revisited the learning objects	# Learner (user_ID)-(number_of_submissions)-Scrom (id)
C12/A1	# Distinct Learning objects completed	# Learner (user_ID)-(number_of_submissions)-Scrom (id)

Relatedness

To calculate Relatedness (Calculates similarly*):

$$Rel(s,w) = \frac{\sum_{R_i} \left(B_{R_i} \cdot \frac{X_{R_i}}{X_{R_i}^{\max}} \right)}{N}$$

Where:

- $\mathbf{R_i}$ is a feature where i∈[1,N] and N is the number of features in **R**. **'R'** represents the group of features used in the computation of *Relatedness* (see table below) for a particular learning scenario. Not all features in the Relatedness table below are mandatory or exhaustive.
- $\mathbf{X_{Ri}}$ is the value of R_i for the student (s) in the week (w), normalised by dividing it by $X_{R_i}^{\max}$, which is the maximum value of R_i that week (w) for the whole class, i.e., the highest score for Ri among all students;

- B_{Ci} is the weight of feature R_i and should be a value between [0,1]; this weight allows different constructs to influence the result in a different way.

- Rel(s,w) ∈ [0,1] is normalised by dividing the result by the number of constructs (N) in **R**

Table 3. *Relatedness Features*

(All values are calculated in a timeframe W (for example, W = one week)

Features	Description	Mapping Moodle Ontology
R1	# Posts created in the forum	# Learner (user_ID) - (number_of_posts) - Forum (id)
R2	# Comments posted in the forum	# Learner (user_ID) - (number_of_submissions) - Forum (id)
R3	# Comments received in their post	# Learner (user_ID) - (number_of_discussions) - Forum (id)
R8/A13	# Clicks in Forums	# Learner (user_ID) - (clicks) - Forum (id)
R9/A8	Σ Time spent on learning contents	# Learner (user_ID)-(time)-Scrom (id)

Annex B - Example queries outputs

As print screens make the texts too small to read, below we only present the texts included in each section of the query.

Query: Give me information about learner with username "***" in module "MODULE:3"**

Feedback

Communication skills

Forum: Overall Evaluation | Topic 1

📊 **Performance**

Indicator	Rating	Illustration
🧠 Cognitive ability	🟡 75.0%	-
🎨 Creativity	🟡 75.0%	*Good application/integration of creative ideas as they arise from the intervention. Good application of innovative ideas and tools within the work, as they arise from the intervention.*
🤝 Collaboration	🟠 66.7%	*The trainee has a good understanding of the objectives of this training and how he can apply tools in his daily work. Good organizational skills within the team. Limited ability to make appropriate decisions and actions in collaboration with the team.*
💭 Critical thinking	🟡 75.0%	*Good ability to explore different perspectives or approaches within the work context. Good critical thinking, which is reflected in the answers to the exercises.*

💬 Collaboration	🟡 79.2%	*Good communication skills for better and more effective collaboration with clients. Good ability to use multiple media in order to enrich educational interventions. Excellent communication skills in a variety of environments with different populations. Good ability to approach the client with verbal or non-verbal ways of approaching. Good ability to perceive communication barriers that may make communication with the client difficult. Good understanding of the theoretical framework of the thematic "communication skills".*

📊 Participation profile

Student Participation Profile 👩‍🎓

- Student Type: Very Active Contributor
- Total Sessions: 2
- Publication Sessions: 2
- View Only Sessions: 0
- Publication Rate: 100.0%
- Total Time: 12 minutes 2 seconds.
- Average Time per Session: 6 minutes 1 second.
- Consistent Participation: Yes
- Improved Participation: No

Action Analysis

- Created: 5
- File uploaded: 4
- Reply (replied): 0
- Posts: 9
- Viewed: 0

Session Details

- **Session 1:**
  - ⏰ Session start: 10-12-2024 13:07:21
  - 🏁 Session End: 10-12-2024 13:19:23
  - ⏱️ Duration: 12 minutes 2 seconds minutes
- **Session 2:**

- ⏱️ Duration: 0 sec. minutes

Quiz: EXERCISE 1: Managing Communication with Different Types of Clients

📊 Performance

Indicator	Rating	Illustration
🧠 Cognitive ability	🌟 100.0%	-

📊 Participation profile

Student Engagement Profile 🧑‍🎓

- Learner Type: Quick Quiz Completion in One Attempt
- Total Attempts: 1
- Completed Attempts: 1
- Overall Completion Rate: 100.0%
- Total Time: 34 minutes 56 seconds.

Frequency of Actions 📊

- Started: 1
- Views: 7
- Autosaved: 27
- Update (updated): 6
- Submitted: 1
- Review (reviewed): 1

Effort Details 📝

- Attempt 1 (Completed ✅)
  - ⏰ Start: 10-12-2024 12:02:11
  - 🏁 End: 10-12-2024 12:37:07
  - ⏱️ Duration: 34 minutes 56 seconds.

⚠️ Unresearched material

- 📋 Book: LET'S EXAMINE THEORY AND HISTORY....
- 📋 Book: WHAT IS NON-VERBAL COMMUNICATION?
- 📋 Book: DOs AND DON'TS
- 📋 Book: COMMUNICATION BARRIERS
- 📋 Feedback: One more question to go!

Guidelines for course design

"Dear Teacher,

Below are comprehensive guidelines that address both improving lesson design and supporting the individual performance of the learner with username "gp1270" in Communication Skills . The guidelines focus on enhancing the overall learning experience and developing the 4Cs (Creativity, Collaboration, Critical Thinking, Communication) through Forum and Quiz activities, in accordance with the TESA framework.

Communication skills

Student Evaluation

The learner "*****" shows a balanced performance with good performance in cognitive ability (75%), creativity (75%), critical thinking (75%) and communication (79.2%) in the Forum: Overall Assessment | Topic 1 , while collaboration shows a lower performance (66.7%). In the Quiz: EXERCISE 1: Managing Communication with Different Types of Clients , the cognitive ability is excellent (100%). The learner is characterized as a very active contributor in the Forum, with full participation and content production, but did not respond to posts by others (zero responses). In the Quiz, he completed the effort quickly and successfully, but there are significant unstudied materials that could further enhance learning.

Lesson Planning Guidelines

1. **Strengthening Collaborative Learning:** Incorporate structured group activities that require active interaction and decision-making to improve collaboration, which is showing weaknesses.
2. **Integrate Feedback and Reflection:** Add reflection and self-evaluation phases after each activity to enhance critical thinking and metacognitive skills.

3. **Integrated Material Management:** Encourage comprehensive study of unstudied material (unstudied material), through guided activities and reminders, to support deeper understanding and preparation for assessments.

Forum: Overall Evaluation | Topic 1

- **Limitations:** Limited ability to make decisions and act in collaboration with the team. Zero responses to others' posts.
    - **Instructions:**
        a. Incorporate guided activities that require sharing ideas and responding to posts, promoting active collaboration.
        b. Use tools that support group organization and decision-making (e.g. shared documents, votes).
        c. Encourage the development of problem-solving strategies in a team context, with clear roles and responsibilities.
        d. Enhance critical thinking through questions that ask for analysis of different perspectives and documentation of opinions.
        e. Promote the use of multimodal communication media (text, image, video) to enhance communication and creativity.
    - **Rationale:**
      According to the "Classroom Implementation Activities" phase of the TESA framework, enhancing collaboration and communication through structured group activities and the use of technological tools supports the development of the 4Cs. Guidance and active participation help to address cognitive difficulties and integrate new knowledge, while multimodal communication enhances understanding and expression. Incorporating reflective questions and promoting critical thinking aligns with the "Purpose, Objectives and Learning Outcomes" phase of TESA, improving the quality of learning.

Quiz: EXERCISE 1: Managing Communication with Different Types of Clients

- **Limitations:** A significant portion of the material has not been studied (5 books and 1 feedback).
    - Instructions:
        a. Incorporate optional review and consolidation activities for unstudied material before the Quiz.
        b. Promote self-regulated learning through guided self-assessment and reflection questions.
        c. Use technological tools that allow progress monitoring with notifications for unstudied material.

d. Encourage the development of critical thinking strategies through questions that require analysis and synthesis of knowledge.
e. Offer feedback that links answers to specific points in the training material.

- **Rationale:**
  The "Evaluate the Educational Scenario" phase of TESA emphasizes the importance of feedback and self-regulation for improving learning. Incorporating gap-filling activities and using technology tools support the achievement of learning objectives and the development of critical thinking. Promoting self-assessment and reflective learning enhances metacognitive competence, critical for successful completion of assessments.

With the above directions, the aim is to improve both the overall design of the course and the strengthening of the abilities of the "gp1270" learner in all dimensions of learning, with an emphasis on the development of the 4Cs and the effective use of technologies.

Kind regards,
augMENTOR"

Recommendations

Dear student,

I observe that you have strong interpersonal and problem-solving skills, as well as solid self-awareness, elements that help you approach your academic obligations with seriousness and consistency. Your performance is generally good, with high scores in cognitive and communication skills, while there is room for improvement mainly in team collaboration and decision-making within a group context. Your participation is very active, with full involvement in publications and quizzes, which shows commitment and interest in the course.

Cognitive Ability (knowledge)

- Average score: 87.5/100
- Analysis: In the Forum: Overall Assessment - Topic 1 you received 75.0/100, which shows that you have a good understanding and application of knowledge, but there is room for improvement. In the Quiz: EXERCISE 1: Managing Communication with Different Types of Clients, your score was excellent, 100/100, showing that you can complete the cognitive requirements quickly and accurately.

- Limitations: The difference between the Forum and Quiz scores suggests that the application of knowledge in more complex or collaborative environments may need further reinforcement.
- Recommendations:
    - Focus on activities that combine theory and practical application to enhance the transfer of knowledge to real-world scenarios.
    - Use self-assessment and reflection tools to identify areas that need further study.
    - Spend more time studying the unstudied resources (e.g. books 26, 27, 28, 38) to deepen your knowledge.

Creativity

- Average score: 75.0/100
- Analysis: In the Forum: Overall Evaluation - Topic 1 your score was 75.0/100, with a positive reference to the good implementation of innovative and creative ideas that emerged from the intervention. This shows that you can incorporate creative solutions, but there is room for further development.
- Limitations: Creativity seems to be limited to specific contexts and may not be fully expressed in all tasks or collaborations.
- Recommendations:
    - Incorporate brainstorming and alternative thinking techniques more systematically into all your work.
    - Look for opportunities to experiment with new tools and methods within the lesson.
    - Collaborate with classmates to exchange ideas and creatively solve problems.

Collaboration

- Average score: 66.7/100
- Analysis: In the Forum: Overall Assessment - Topic 1 your score was 66.7/100. The feedback indicates that you have a good understanding of goals and have good organizational skills within the team, but you show limited ability to make appropriate decisions and actions in collaboration with others.
- Limitations: Difficulty in making decisions and taking action within the team may affect the effectiveness of your collaboration.
- Recommendations:
    - Practice group activities that require collective decision-making, such as discussions and group projects.

- Ask for feedback from your team members to improve your communication and contribution.
- Use project management and organization tools to enhance your active participation.

Critical thinking

- Average score: 75.0/100
- Analysis: In the Forum: Overall Assessment - Topic 1 your score was 75.0/100, with positive reference to your ability to explore different perspectives and apply critical thinking in your answers. This shows that you have a good foundation, but you can go further.
- Limitations: Critical thinking seems to be limited to specific contexts and may not always apply to more complex or multidimensional situations.
- Recommendations:
  - Incorporate exercises that require analysis and evaluation of multiple sources and points of view.
  - Practice problem solving using methods such as SWOT analysis or the dialogic method.
  - Participate in discussions that promote the questioning and documentation of opinions.

Communication

- Average score: 79.2/100
- Analysis: In the Forum: Overall Assessment - Topic 1 , your score was 79.2/100, with excellent communication skills that include using multiple media, reaching diverse populations, and a good understanding of communication barriers. This shows that you have a strong ability to communicate effectively in a variety of environments.
- Limitations: No significant weaknesses identified, however continuous improvement and practice in different contexts will further strengthen your skills.
- Recommendations:
  - Actively participated in discussions and presentations with different audiences.
  - Use a variety of media (visual, verbal, digital) to enrich your communication.
  - Ask for feedback to improve your understanding and expression.

Summary: Your performance is strong in cognitive and communication skills, with significant active participation and consistency. However, you need to focus more on developing

collaboration and critical thinking in group settings, as well as deepening your creativity. I suggest you carefully study all the unstudied resources, devote more time to studying, and discuss any difficulties with your instructors or classmates. Active participation in group activities and the use of organizational and self-assessment tools will help you improve your weaknesses and further develop your skills.

Best regards,
augMENTOR

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Annex C - Example set of recommendations

Input for course 'Adult education and lifelong learning: Applied technologies, practices, and training for health professionals (IASIS pilot course 2024-2025)' (educators involved: 19, learners participating: 255)

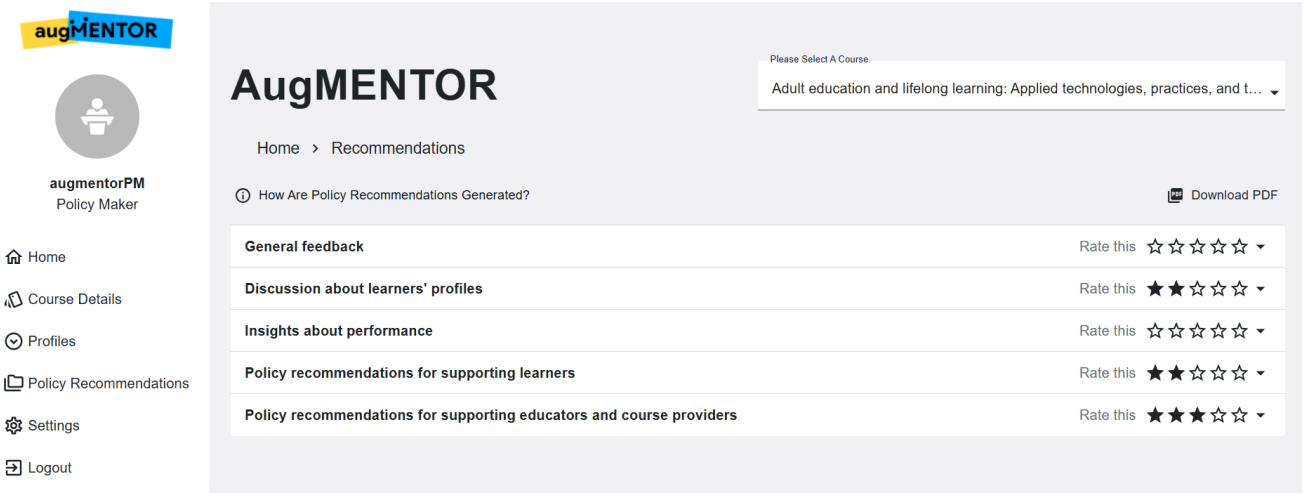

Figure 7. *Policy Recommendations screen*

General feedback

In summary, the analysis of the augMENTOR profiles reveals distinct strengths and weaknesses across cognitive and 21st-century skills. The analysis of the performance data reveals distinct strengths and weaknesses across the IASIS profiles in relation to the course's cognitive and 21st-century skill demands. IASIS_A learners show solid collaboration and communication skills but require support in cognitive and creative domains. IASIS_B learners demonstrate strong cognitive and critical thinking abilities but need targeted development in communication. IASIS_C learners excel in autonomy, collaboration, and critical thinking but have room for growth in communication and creativity. These patterns align with their characteristic profiles and highlight specific educational needs within the course context. The proposed policies, grounded in the TESA framework, address these needs by recommending tailored course designs and educator strategies that scaffold cognitive development, enhance creativity, and foster communication and collaboration. By integrating technology-augmented activities, formative assessments, and reflective practices, the policies aim to improve learner engagement and skill acquisition. The anticipated outcome is a more inclusive and effective learning environment that supports the diverse profiles of mental health professionals, ultimately enhancing their professional competencies and readiness for real-world challenges.

Discussion about learners' profiles

augMENTOR profile: IASIS_A

Characteristics: Solid interpersonal and problem-solving skills, grounded self-awareness, and steady but improvable academic performance.

Description: The IASIS_A profile reflects learners who demonstrate notable strengths in communication and problem-solving, with a reliable sense of autonomy and relatedness. Their communication skills and time management are considered solid, and are confident that they perform 'quite well' in these areas. A strong awareness and inclusion of minority groups in daily interactions is also a characteristic, suggesting a thoughtful and socially conscious disposition. Problem-solving skills are a clear asset, consistently rated positively. Autonomy and competence are present at medium to high levels, and relatedness-how connected they feel to others-is particularly strong, with most learners in this group scoring in the high category. However, academic indicators show moderate outcomes. Creativity and cognitive performance fall into the average range while collaboration is somewhat stronger, suggesting that learners with this profile work well in group contexts. Critical thinking scores are modest, and communication grades, while varied, tend to center a bit above average, indicating room for growth in formal expression despite strong self-perception.

augMENTOR profile: IASIS_B

Characteristics: Well-rounded, confident learners who not only excel academically but also exhibit social awareness and a strong sense of belonging.

Description: The IASIS_B profile represents learners with a more robust and consistent performance across most domains. Self-assessments are generally confident, mostly considering communication and time management skills at the highest levels. Deep commitment to inclusivity is portrayed, leading in ratings for the inclusion of minority groups, and demonstrating excellent problem-solving capabilities. These learners also perceive the thematic content of their courses as highly helpful, suggesting they are both engaged and benefiting from the structure. Autonomy and competence levels are high, and demonstrate strong connections to their peers. Academically, learners that fall under this profile perform well, with creativity and cognitive skills both well above average. Their collaboration skills are solid, critical thinking is well-developed, and their communication grades align with their self-perception, also averaging well above average.

augMENTOR profile: IASIS_C

Characteristics: High autonomy, intellectually capable individuals who thrive in collaborative and higher-order thinking tasks, positioning them as leaders in both academic and social-emotional domains.

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Description: The IASIS_C profile corresponds to learners with high performance across several key indicators. Learners in this profile showcase strong creativity, with the high median scores, also excelling in critical thinking and communication-both in self-assessment and in graded performance. Autonomy is the most developed, with the greatest number reporting 'very high' levels, and their sense of competence and relatedness is equally strong. Cognitive performance is solid, averaging quite above average, and collaboration is particularly impressive. While time management and communication self-assessments are good, and problem-solving abilities are reliable, their inclusion of minority groups is moderate. Learners under this profile tend to find the thematic content helpful.

Insights about performance

#1 Learners with solid interpersonal and problem-solving skills, grounded self-awareness, and steady but improvable academic performance. (augMENTOR profile: IASIS_A)

• **Analysis:** The IASIS_A profile demonstrates moderate cognitive skills with scores ranging from 58.3 to 73.0, showing steady but improvable academic performance. Their creativity scores are relatively balanced but slightly lower in some areas compared to other profiles. Collaboration and communication skills are strong, with scores mostly above 70, reflecting solid interpersonal skills. Critical thinking is also well developed but shows room for growth.

• **Key Observations:**

• Strengths: Collaboration, Communication, Critical Thinking

• Weaknesses: Cognitive skills in some areas, Creativity in certain dimensions

#2 Learners with well-rounded, confident learners who not only excel academically but also exhibit social awareness and a strong sense of belonging. (augMENTOR profile: IASIS_B)

• **Analysis:** IASIS_B learners show the highest cognitive and critical thinking scores among the profiles, indicating strong academic and analytical capabilities. Creativity and collaboration scores are also high, supporting their well-rounded and confident learner characteristics. Communication skills are solid but slightly lower than collaboration and critical thinking.

• **Key Observations:**

• Strengths: Cognitive skills, Critical Thinking, Collaboration, Creativity

• Weaknesses: Communication slightly less strong compared to other skills

#3 Learners with high autonomy, intellectually capable individuals who thrive in collaborative and higher-order thinking tasks, positioning them as leaders in both academic and social-emotional domains. (augMENTOR profile: IASIS_C)

• **Analysis:** IASIS_C learners exhibit high autonomy and excel in collaboration and critical thinking, with some of the highest scores in these areas. However, their cognitive skill scores are slightly lower compared to IASIS_B and IASIS_A, and creativity scores show variability. Communication skills are adequate but not as strong as collaboration.
• **Key Observations:**
• Strengths: Collaboration, Critical Thinking, Autonomy
• Weaknesses: Cognitive skills, Communication, Creativity in some dimensions

Policy recommendations for supporting learners

#1 Supporting learners with solid interpersonal and problem-solving skills, grounded self-awareness, and steady but improvable academic performance.

Policy recommendation: Future courses should be designed to leverage the strong interpersonal and collaboration skills of IASIS_A learners while providing targeted support to enhance their cognitive and creative abilities. Emphasis should be placed on scaffolded problem-solving activities and creative thinking exercises integrated with collaborative tasks to build confidence and academic performance.

Guidelines on the recommendation:

• **Scaffolded Cognitive Development:** Activities should be structured progressively to build cognitive skills, incorporating real-life problem-solving scenarios relevant to mental health professionals (TESA Phase E: Activities for Implementation in the Classroom).
• **Creativity Enhancement Workshops:** Creative tasks should be embedded within collaborative projects to stimulate divergent thinking and innovation, supporting the development of creativity alongside communication (TESA Phase E).
• **Collaborative Reflection Sessions:** Regular peer discussion and reflection activities should be included to strengthen self-awareness and critical thinking, fostering deeper understanding and metacognitive skills (TESA Phase E and Phase F: Metacognitive Activities).
• **Integrated Communication Practice:** Communication exercises should be contextualized within professional scenarios to improve clarity and effectiveness, addressing slight weaknesses in expressive skills (TESA Phase E).
• **Use of Technology for Interactive Learning:** Digital tools facilitating scenario-based learning and peer feedback should be incorporated to engage learners actively and support diverse learning styles (TESA Phase D: Teaching Material and Technology-Augmented e-Activities).

#2 Supporting learners with well-rounded, confident learners who not only excel academically but also exhibit social awareness and a strong sense of belonging.

Policy recommendation: Future courses should capitalize on the well-rounded and confident nature of IASIS_B learners by offering advanced challenges that promote leadership in collaborative settings and enhance communication skills. The course design

should integrate complex problem-solving tasks and inclusive group activities to maintain engagement and foster social awareness.

Guidelines on the recommendation:

- **Advanced Problem-Solving Modules:** Complex case studies and decision-making scenarios should be included to further develop cognitive and critical thinking skills at a higher level (TESA Phase E).
- **Communication Skill Intensives:** Targeted modules focusing on professional communication nuances, including active listening and empathetic dialogue, should be implemented to address communication gaps (TESA Phase E).
- **Leadership in Collaboration:** Group activities should be designed to encourage leadership roles, promoting social awareness and a sense of belonging (TESA Phase E).
- **Diversity and Inclusion Simulations:** Interactive exercises emphasizing diversity and inclusion should be integrated to deepen understanding and application of these concepts in professional practice (TESA Phase E).
- **Formative Assessments with Feedback Loops:** Frequent formative assessments with detailed feedback should be used to monitor progress and adapt learning paths (TESA Phase F: Evaluation).

#3 Supporting learners with high autonomy, intellectually capable individuals who thrive in collaborative and higher-order thinking tasks, positioning them as leaders in both academic and social-emotional domains.

Policy recommendation: Future courses should be tailored to support the high autonomy and leadership potential of IASIS_C learners by providing opportunities for self-directed learning and advanced collaborative problem-solving. Emphasis should be placed on enhancing communication skills and creativity through innovative and flexible learning activities.

Guidelines on the recommendation:

- **Self-Directed Learning Projects:** Learners should be encouraged to design and lead projects that integrate course themes, fostering autonomy and higher-order thinking (TESA Phase E).
- **Creative Collaboration Tasks:** Activities should promote creative problem-solving within teams, leveraging their strength in collaboration and critical thinking (TESA Phase E).
- **Communication Skill Development:** Structured communication workshops focusing on clarity, persuasion, and professional dialogue should be incorporated to strengthen weaker communication skills (TESA Phase E).
- **Peer Mentoring Programs:** Opportunities for IASIS_C learners to mentor peers should be created to enhance leadership and social-emotional skills (TESA Phase E).
- **Technology-Enhanced Reflective Practices:** Use of digital portfolios and reflective journals should be encouraged to support metacognitive development and continuous improvement (TESA Phase F).

Policy recommendations for supporting educators and course providers

#1 Supporting learners with solid interpersonal and problem-solving skills, grounded self-awareness, and steady but improvable academic performance.

Policy recommendation: Educators should be equipped to support IASIS_A learners by implementing structured scaffolding, fostering collaborative learning environments, and integrating creativity-enhancing strategies. Emphasis should be placed on continuous formative assessment and personalized feedback to build confidence and academic skills.

Guidelines on the recommendation:

- **Structured Scaffolding Implementation:** Educators should break down complex cognitive tasks into manageable steps, providing clear guidance weekly (TESA Phase E).
- **Facilitation of Collaborative Learning:** Group activities should be organized to maximize peer interaction and support, with roles assigned to encourage participation (TESA Phase E).
- **Creativity Stimulation Techniques:** Educators should introduce brainstorming sessions and creative problem-solving exercises regularly (TESA Phase E).
- **Formative Micro-Assessments:** Frequent low-stakes assessments should be conducted to monitor progress and inform instruction (TESA Phase F).
- **Personalized Feedback Delivery:** Timely and specific feedback should be provided to address individual learner needs (TESA Phase F).
- **Use of Digital Interactive Tools:** Educators should integrate technology that supports scenario-based learning and peer feedback (TESA Phase D and E).
- **Encouragement of Reflective Practice:** Reflection prompts and discussion forums should be facilitated to enhance metacognitive skills (TESA Phase F).

#2 Supporting learners with well-rounded, confident learners who not only excel academically but also exhibit social awareness and a strong sense of belonging.

Policy recommendation: Educators should focus on challenging IASIS_B learners with advanced content and leadership opportunities while supporting communication skill refinement. Strategies should include differentiated instruction, leadership role assignments, and inclusive group dynamics management.

Guidelines on the recommendation:

- **Differentiated Instruction Design:** Educators should tailor tasks to challenge learners appropriately, providing extension activities weekly (TESA Phase E).
- **Leadership Role Facilitation:** Assign leadership roles in group work to foster responsibility and social awareness (TESA Phase E).

• **Communication Skills Coaching:** Targeted workshops and role-playing exercises should be scheduled to enhance communication (TESA Phase E).

• **Inclusive Group Dynamics Management:** Educators should monitor and guide group interactions to ensure inclusivity and respect (TESA Phase E).

• **Regular Formative Feedback:** Implement ongoing assessments with constructive feedback to guide learner development (TESA Phase F).

• **Integration of Diversity Simulations:** Use scenario-based activities to deepen understanding of inclusion (TESA Phase E).

• **Encouragement of Peer Feedback:** Facilitate peer review sessions to build critical evaluation skills (TESA Phase F).

#3 Supporting learners with high autonomy, intellectually capable individuals who thrive in collaborative and higher-order thinking tasks, positioning them as leaders in both academic and social-emotional domains.

Policy recommendation: Educators should support IASIS_C learners by promoting autonomy through self-directed projects, enhancing communication skills, and providing leadership opportunities. Strategies should include flexible learning paths, mentorship facilitation, and technology integration for reflective practice.

Guidelines on the recommendation:

• **Promotion of Self-Directed Learning:** Educators should provide frameworks for independent projects with periodic check-ins (TESA Phase E).

• **Communication Skills Workshops:** Regular sessions focusing on professional communication should be integrated (TESA Phase E).

• **Mentorship Program Coordination:** Facilitate peer mentoring roles to leverage leadership strengths (TESA Phase E).

• **Flexible Learning Pathways:** Allow learners to choose topics or methods within the course framework (TESA Phase E).

• **Use of Digital Portfolios:** Encourage maintenance of e-portfolios for reflection and assessment (TESA Phase F).

• **Collaborative Problem-Solving Facilitation:** Organize complex group tasks that require creative solutions (TESA Phase E).

• **Frequent Reflective Activities:** Implement journaling and discussion prompts to support metacognition (TESA Phase F).

Annex D - Analysis of the evaluation for the policy recommendations part of the platform

1. Quantitative Quality & Presentation Rating (Scale 1-5)

The core question evaluating the overall presentation of policy recommendations received a mean score of 4.45 out of 5.00, indicating high satisfaction among respondents.

Policy Recommendations Presentation Rating: 4.45
Course Overview section Rating: 4.50
Profile Presentation Rating: 4.32

Key Insight: All core components, including the Policy Recommendation presentation, achieved a median and mode of 5.00, suggesting the majority of users found the quality and presentation to be excellent.

2. Validation and Adoption Intent

The desire to adopt the platform serves as a direct validation of the perceived utility and quality of the recommendations.

Yes: 72.2%
I don't know: 22.2%
No: 5.6%

Key Insight: Nearly three-quarters (72.2%) of respondents indicated they would be willing to adopt the augMENTOR platform for policy recommendations, strongly validating the platform's value proposition.

3. Usefulness of Policy Recommendation Sections

The perceived usefulness of the two dedicated policy recommendation sections was exceptionally high, confirming their relevance to the target audience.

Policy recommendations for supporting educators and course providers section:
63.2% (very useful), 21.1% (Quite useful), 84.3% (Total Positive)
Policy recommendations for supporting learners section:
57.9% (very useful), 15.8% (Quite useful), 73.7% (Total Positive)

Key Insight: Recommendations targeted at educators and course providers were perceived as the most useful section overall, with 84.3% of respondents rating them as "Very useful" or "Quite useful."

4. Demographic Analysis & Qualitative Feedback

The majority of feedback from Academic and Instructor roles remains overwhelmingly positive. This confirms that the lower average ratings are isolated to single responses from other Northern European countries.

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Mean Policy Rec Presentation Rating by Role (Top 5)

Role	Mean Policy Recommendations Presentation Rating
Academia	5.00
Academic teacher	5.00
Assistant Professor of Pedagogy	5.00
Associate Professor in ICT in Education	5.00
Instructor and researcher	5.00

Mean Policy Rec Presentation Rating by Country

Country	Mean Policy Recommendations Presentation Rating
Bulgaria	5.00
Greece	4.92
Belgium	4.00
Sweden	3.00
Norway	2.00

Key Insight: The low average ratings from NORWAY (2.00) and SVERIGE (3.00) remain the most critical outliers. While the overall platform quality is validated, these scores indicate a potential flaw in cultural fit, specific implementation, or language/contextual application for these regions.

Qualitative Feedback (Comments)

The limited free-text comments were generally positive, supporting the quantitative data. One comment suggested a possible issue with the workshop execution, not the platform's content.

Annex E - User requirements evaluation and final overview

Table 4. *User requirements evaluation and final overview*

OpReq1: Enhancing feedback and Inquiry based learning	
Requirements coverage based on preliminary evaluation	The platform partially meets this user requirement via educator-mediated, explainable feedback and recommendations, but not explicitly for inquiry. Recommendations are produced by a generative model following the educator's query which takes the natural-language question and automatically translates it into a Cypher query, Neo4j's query language, to fetch relevant facts from the Knowledge Graph and the database. augMENTOR Profiles exist but do not drive learners recommendations. At the time of the interview, the technical partners (WP5) stated that it was an ongoing work. Later tests showed that the platform can provide recommendations which take augMENTOR profiles into account, showing continuous integration of learner profiles in the feedback and recommendation.
Final overview of covering requirements	The platform meets this requirement to a large degree as it offers guidelines to educators and recommendations to learners following the TESA educational framework (including targeted references to TESA for educators) which is produced in the framework of the project. TESA, like Inquiry Based Learning (IBL) is a student-centered approach that focuses on skills development through active participation while also focusing explicitly on the integration of emerging technologies. While IBL is not directly integrated since the platform integrates the framework produced by the project, through TESA, the platform supports enhancing feedback and the inquiry-based learning rationale by providing learners with clear, actionable insights on specific indicators, along with contextual explanations and references to relevant resources. This approach allows both educators and learners to identify strengths and areas for improvement, encourages reflective practice, and facilitates learning through targeted inquiry, aligning well with the principles of feedback-driven and inquiry-centered education. Even though it is not directly linked to the platform, to have a complete overview of this requirements as it is addressed by the project, we would also like to mention that the TESA framework is essentially a structured design and implementation guide that uses and scaffolds the principles

	of IBL and other constructivist theories (like activity theory and social constructivism) for an AI-enhanced environment. The TESA Framework is not an alternative to IBL; it is an overarching instructional design model used to deliberately implement IBL principles within a structured, data-rich environment. TESA provides the scaffolding for the teacher's work (the "hidden strategies"), ensuring the student-centered activities (the IBL cycle) effectively target the development and assessment of the 4Cs through technology. The emphasis on Phase B (Cognitive Analysis) ensures that the inquiry starts at the student's Zone of Proximal Development, maximizing the benefit of the inquiry experience.

OpReq2: Personalised learning pathways and recommendations	
Requirements coverage based on preliminary evaluation	As augMENTOR is primarily a recommendation engine for teachers, the platform does not directly provide learning pathways to students. It does however generate teaching recommendations that take augMENTOR profiles into account, which should enable the teacher to reflect and improve their teaching and pathways. Personalised learning pathways at an individual learner level is not implemented at the time of this interview. The explainable recommendations are generated through the same processes in OpReq1
Final overview of covering requirements	For Piot #1, #2 and #3, the nature of the course structured in Moodle does not allow the learner to choose any activities and personalize their learning path directly. However, personalization can occur indirectly based on formative assessment. Educators and learners receive recommendations based on their query feedback according to TESA and the augMENTOR profiles. Depending on the query (those that do not include specific learners), recommendations also include wider guidelines for the design of the entire course or dedicated models. Thus based on the recommendations of the platform, educators are able to adjust their course at class level and at learner level. Moreover, personalised learning pathways, were implemented for Pilot #4. Learners could potentially make a query to ask for recommended rooms (learning courses and activities); however, later developments in the TryHackMe platform which force users to follow pre-defined specific pathways do not allow users to choose the rooms they engage in and thus personalize their learning path.

OpReq3: Data driven course design and delivery	
Requirements coverage based on preliminary evaluation	Similar to OpReq1 and 2, recommendations for course design and delivery are generated by a generative model (explanation generation model) which retrieves input from the KG and performs an analysis. These recommendations can support curriculum design and teaching practices in certain contexts. The learner's needs are implicit in the system and the platform can only check if learners have accessed the resources and give recommendations accordingly.
Final overview of covering requirements	Recommendations and course design guidelines are data driven as they are generated based on the data received from the course implementation. Following the early evaluation results, detailed interaction data, including clicks, submissions and time spent, were also captured. The updated KG records activity-level statistics, presented in section 2.3. As also mentioned in that section, these abstractions provide educators with an interpretable overview of learning tendencies at a glance, while preserving access to the detailed activity trace for deeper analysis.

OpReq4: Reflective learning and applications in practice	
Requirements coverage based on preliminary evaluation	augMENTOR generates explainable recommendations based on learners' data and profile they belong to, which the teacher can share with the learner to prompt reflection. The platform provides learning analytics which can also trigger reflection but there is no dedicated mechanism in the augMENTOR platform to induce reflection or support application of knowledge in practice, as the platform is designed to be query driven such that the teacher must first directly inquire about a specific learner to retrieve information about the student.
Final overview of covering requirements	This requirement is addressed by integrating transversal skill development and data-driven feedback into the system. The platform enables reflection through a dual-loop mechanism: a) Learner-Initiated Reflection: Learners can directly submit queries to the system and receive explainable feedback based on their data and the augMENTOR Learner Profile. This immediate, data-backed response directly addresses performance gaps and promotes a moment of self-assessment and regulation.

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	b) Teacher-Mediated Application: The final, key step of connecting reflection to real-world application is handled by the educator, ensuring the insights are pedagogically sound and contextually appropriate. The platform provides the necessary tools (Learning Analytics visualization and AI-generated recommendations) for the teacher to perform this metacognitive scaffolding, bridging the learning environment's context to the external reality. While the AI provides the data and the suggestions, the system maintains a "human-in-command" approach, relying on the teacher's expertise to fully operationalize reflection on practical application in the learner's development. Finally, it should be noted that the core strategy is also built on fostering the 4Cs, which are explicitly recognized as competencies that give learners the ability to adapt, innovate, and problem-solve in various challenges—the fundamental mechanism for applying knowledge in real-world practice. The entire pedagogical model, including the TESA micro-level model and scenario design, is structured around challenging learners with problem-based, socially situated activities (e.g., real-life case studies, collaborative problem-solving) to develop these skills,

OpReq5: Addressing learner engagement challenges	
Requirements coverage based on preliminary evaluation	augMENTOR models engagement and motivation indicators in the augMENTOR Profile. The pre-trained generative model uses the profiles along with TESA guidelines to give insights about the learners engagement profile. This aligns with the augMENTOR's position to advise educators to facilitate engagement rather than to run learner-facing interventions. The platform provides course-design features. The generative model used is pre-trained LLM that uses prompting based on the integrated KG. Furthermore, much of the ontology (at the time of testing) is a composite/quantitative set of indicators listed which limits the granularity of feedback it can provide.
	The platform effectively addresses learner engagement challenges by providing personalized feedback, highlighting areas where learners may struggle or have not yet engaged with the material as well as offering

	targeted recommendations for improvement. By combining performance indicators, resource suggestions, and contextual explanations, it assists educators identify engagement gaps and supports learners in taking proactive steps to stay involved, fostering a more interactive and responsive learning experience. While the platform currently uses an off-the-shelf LLM and a composite set of quantitative indicators, it leverages these tools in a highly structured and pedagogically informed way. The LLM is guided by the TESA framework and takes into account the learner's performance on the 4Cs (Creativity, Collaboration, Communication, Critical Thinking), as well as learner characteristics and engagement with the class. Additionally, the platform utilizes pre-defined augMENTOR profiles—generated from pre-pilot data such as questionnaires, grades, and engagement metrics—which provide detailed insights into each learner's strengths, behavior, performance, and engagement patterns. This combination allows the platform to deliver nuanced, actionable feedback and recommendations, supporting the learning process. While it does not yet provide concrete course-design tools, recommendations are based on a dedicated pedagogical framework. These features enable targeted guidance that can complement traditional instructional design, and future iterations could integrate more granular ontologies and course-design functionalities to further enhance the platform's capability

OpReq6: Pedagogical support and Interaction enhancement	
Requirements coverage based on preliminary evaluation	AugMENTOR can provide insights and generate explainable, teacher-facing recommendations grounded in TESA, learner data and augMENTOR profiles, which an educator can use to foster interactions, support students' students pedagogically, and adjust grouping decisions. Recommendations are handled by the generative model, taking TESA and the learner model (partially), and learner profiles into account. The TESA and the learner models are pedagogically informed and designed, and consequently, while augMENTOR does streamline and offload aspects of pedagogy, the concrete steps or decisions are still left to the teacher.
Final overview	The augMENTOR platform meets this requirement by leveraging its core

of covering requirements	AI-boosted pipelines to support educators, rather than directly automating complex pedagogical tasks. The system utilizes the Feedback Generation Pipeline and the Recommendation Generation Pipeline to transform user queries into actionable, evidence-based guidance and explainable recommendations grounded in learner profiles and analytics, which directly enable the educator to monitor engagement and competencies. The platform's success lies in effectively removing the burden of manual data analysis, thereby empowering the educator to execute better pedagogical practices, such as informed grouping decisions and enhanced learner interaction, while strictly maintaining the "human-in-the-loop" role for all final pedagogical decisions. The platform does not directly form collaborative groups or automate other complex pedagogical tasks; instead it provides the data and recommendations that enable the educator to make those decisions.

Func1: Adaptive learning and skill development	
Requirements coverage based on preliminary evaluation	The platform tracks various indicators of skills acquisition over time through regular data extraction and also updates the augMENTOR profiles. Then, it produces personalised recommendations in accordance to TESA and the transversal skills rubric descriptions, that an educator, and subsequently the learner, can view. Real-time assessments of specific skills or objectives are not implemented, but are done so on a weekly basis (limitations of access from Moodle platform and other constraints). AugMENTOR provides competency level (cognitive, creativity etc) learning analytics based on TESA and the transversal skills rubric descriptions .
Final overview of covering requirements	The augMENTOR platform addresses this requirement by implementing a robust, data-driven architecture centered on the augMENTOR Learner Model. The core strategy is to provide personalized recommendations and feedback that empower the educator to execute adaptive instruction grounded on the TESA framework. For skills development in particular, the creative pedagogy aspect included in TESA is used skills development-related course design instructions and assessment through rubrics to provide competency-level learning analytics. The platform then uses this rich, personalized context to generate

	explainable recommendations that the educator can share with the learner, thus facilitating the process of adaptive inclusive learning and skills acquisition.

Func2: Inclusivity and accessibility	
Requirements coverage based on preliminary evaluation	The platform generates explainable recommendations at an individual learner level, which can help target support to diverse learners. It also supports multiple languages. Data is pseudonymised at server side. Low connectivity operation and user experience considerations are not documented.
Final overview of covering requirements	The system achieves pedagogical inclusivity by adopting privacy-by-design, processing and storing only pseudonymized data server-side to protect participants' identity and remain compliant with data protection laws. Furthermore, it supports diverse learners by offering personalized recommendations and explainable feedback at an individual learner level in multiple languages. Seamless function in low-connectivity environments could be part of future work investigating multimodal accessibility options, such as text-to-voice features and keyboard-only navigation support, alongside dedicated efforts to ensure reliable function in low-connectivity environments.

Func3: Learning analytics and personalised feedback	
Requirements coverage based on preliminary evaluation	AugMENTOR provides personalized, explainable recommendations, feedback, and a learning analytics interface. The platform also allows regular monitoring of students' performance.
Final overview of covering requirements	The augMENTOR platform includes learning analytics information in the feedback generated. Personalized feedback is generated through queries when the query addresses a specific learner. In turn personalised feedback is generated based on the TESA framework and

	contextual information stored in the (KG) to ensure alignment with pedagogical goals.

Func4: Monitoring motivation and engagement	
Requirements coverage based on preliminary evaluation	See OpReq5
Final overview of covering requirements	See OpReq5

Func5: Continuous improvement and reflective teaching	
Requirements coverage based on preliminary evaluation	augMENTOR supports continuous improvement and reflective teaching by giving educators, and the learners, explainable, data-driven recommendations and feedback grounded in data, the augMENTOR profiles, the KG, and TESA framework. These recommendations are provided to the teacher, who can reflect, and adapt instruction.
Final overview of covering requirements	The augMENTOR platform supports continuous improvement and reflective teaching through its query-driven, AI-powered architecture. As courses progress, educators and learners can interact with the platform to receive timely, explainable feedback and actionable recommendations grounded in real course data, learner profiles, and the TESA framework. For educators, the platform functions as an intelligent pedagogical partner, transforming learning analytics into interpretable insights with data-driven course design recommendations, profile-informed guidance on learner strengths and intervention needs, and aggregated performance analytics across modules and indicators. This continuous feedback loop enables educators to reflect critically on their teaching strategies and implement targeted adjustments at individual, group, or course levels before challenges escalate. For learners, the platform supports self-regulated learning by providing

	transparent performance feedback, personalized human-vetted recommendations, and clear visibility into their learning trajectory, fostering metacognitive development. The platform's Human-in-the-Loop mechanism ensures educators' retain full agency to review, edit, and approve AI-generated recommendations, guaranteeing pedagogical soundness.