Higher Education Classroom Of the Future

HECOF D5.1 Pilot monitoring and evaluation methodology

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Authors:	Christian Tismer (NURO) Ioana Ghergulescu (ADAPTEMY)
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Partners

konnektable TECHNOLOGIES	KONNEKT ABLE TECHNOLOGIES LIMITED (KT)	IE	COO
	ETHNICON METSOVION POLYTECHNION (NTUA)	EL	BEN
POLITECNICO MILANO 1863	POLITECNICO DI MILANO (POLIMI)	IT	BEN
NUROMEDIA	NUROMEDIA GMBH (NURO)	DE	BEN
SIMAVI Software Imagination & Vision	SIMAVI SOFTWARE IMAGINATION & VISION	RO	BEN
Adaptemy	ADAPTEMY LIMITED	IE	BEN

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1.1	19.09.2024	NURO	Review Version for WP5 Meeting
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1.3	29.09.2024	NURO	Merged and consolidated version, ready for final review and submission

Executive Summary

This **"Pilot monitoring and evaluation methodology" report** is the first deliverable D5.1 of HECOF Work Package 5: "Pilot testing, evaluation and impact assessment". Objective of this document is the **initial planning of the HECOF piloting**, evaluation, and monitoring in strong collaboration with WP4 the agile development to initiate HECOF phase 3 "Monitoring and evaluation".

HECOF piloting will be implemented at **two pilot universities in the field of chemical engineering**.

- Pilot 1: NTUA, chemical extraction process
- Pilot 2: POLIMI, bioreactor

HECOF follows a state-of-the-art **hybrid development methodology** [2] with Lean/UX in WP2, (see D2.1), learning design in WP3 (see D3.1 and D3.2), and "Agile development of HECOF system" in WP4.

HECOF will be evaluated by **two evaluations**. Objective of evaluation 1 is to gather **user feedback** for the agile development and collect **performance data** from the HECOF system. Objective of evaluation 2 is to assess the outcome and impact of HECOF.

The HECOF **evaluation and monitoring methodology** employs a **mixed-methods approach**, combining quantitative metrics from **system performance** and **learning analytics** with qualitative **feedback from users**. The methodology integrates current research for AI-adaptive learning and VR training to assess the system's impact [3], [4], [5]. **Six evaluation dimensions** are discussed: **a)** Technical functionality, **b)** System performance: system accuracy performance, **c)** Pedagogical impact, **d)** Satisfaction and perceived usefulness, **e)** Usability Evaluation, **f)** Social Impact and Presence.

Implementation of HECOF **phase 3 "Monitoring and evaluation"** is organized in eight subphases:

- **PH3.0:** Planning of methodology (WP5, T5.1 NURO) D5.1 M21
- **PH3.1:** Preparation of pilot activities (WP5, T5.2, E5.1 & E5.2 SIMAVI)
- **PH3.2:** Users Training (WP5, T5.3, E5.2 & E5.4 ADAPTEMY)
- **PH3.3:** Evaluation 1 running and monitoring (WP5, T5.4 SIMAVI)
- **PH3.4:** Analytics of the outcome and refinement of D2.1 & D5.1 by D5.2 M24 (WP5, T5.5 NURO)
- **PH3.5:** Agile development of MVP2
- **PH3.6:** Evaluation 2 running and monitoring (WP5, T5.4 SIMAVI)
- **PH3.7:** Analytics of the outcome and impact assessment by D5.3 M30 (WP5, T5.5 NURO)

WP5 will guide through these phases, based on input from WP2, WP3, and in collaboration with WP4.

T5.2 **Preparation** will refine this initial planning and deploy the first version of the HECOF system in PH3.1. Combined events with T5.3 **User Training** will introduce the pilot partners with the HECOF platform and set up the first evaluation in PH3.2. In this phase the VR exercises will be refined by the educators in collaboration with the developers. PH3.3 will conduct the implementation of the **first evaluation**. In PH3.4 outcome of the first evaluation will be reported by D5.2 "First evaluation of pilot activities & user requirements refinement" as **refinement** of D2.1 and this report. Based on this PH3.5 will **finalize** the HECOF System. The final version of HECOF will be assessed by the **second evaluation** in PH3.6. Findings of WP5 will about user satisfaction and system performance of the HECOF system will be reported with **D5.3 "Final evaluation and impact assessment"**. This report will provide insights to technical aspects, pedagogical impact, satisfaction, perceived usefulness, usability, and social impact for the HECOF approach of a novel AI driven adaptive and immersive learning environment.

This will **achieve milestone MS7 "Second round of pilot activities are implemented"**.

Abbreviations and Acronyms

Abbreviation	Definition
AI	Artificial Intelligence
API	Application Programming Interface
HECOF	Higher Education Classroom of The Future
NTUA	NATIONAL TECHNICAL UNIVERSITY OF ATHENS: ETHNICON METSOVION POLYTECHNION
LPAD	Laboratory of Process Analysis & Design
M#	Project Month Number
MS#	Milestone Number
ML	Machine Learning
POLIMI	POLITECNICO DI MILANO
PH#.#	Phase Number
T#	Task Number
VR	Virtual Reality
W#	Week Number (ISO 8601)
WP#	Work package Number

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1 Introduction

1.1 Purpose of the Document and Follow-Up

This report **D5.1 Pilot monitoring and evaluation methodology"** is outcome of HECOF projects Task **T5.1 "Pilot testing and evaluation methodology"** and discusses the planning of WP5 "Pilot testing, evaluation and impact assessment", the user studies that constitute the HECOF evaluation 1 and evaluation 2, and the metrics applied to continuously assess the usability and performance of the technical components in HECOF. The metrics presented are used in deliverables corresponding to the technical components or evaluation summaries. Timeline in this document is a scaffold **given to T5.2 "Preparation of pilot activities"**. Delivery of this document **initiates HECOF Phase 3 "Monitoring and evaluation (M22 - M29)"**, as described in section 2.2 Phases of WP5.

This deliverable will be **followed up by D5.2 "First evaluation of pilot activities & user requirements refinement"** and **D5.3 "Final evaluation and impact assessment"**. The results of the first user evaluation in pilot 1 and pilot 2 will be reported in deliverable, D5.2 in M24, this deliverable will include refinement of the second evaluation planning and KPI. "WP4 Agile development of HECOF system" will receive D5.2 as refinement of D2.1 "User Requirements and Functional Specifications", for refinement of the development. D5.3 as final resume of WP5 will be delivered to "WP6 Communication, dissemination and exploitation". D5.3 in M30 will conclude phase 3, after the second evaluation was finished and analysed.

1.2 T5.1 Description: Pilot testing and evaluation methodology

As described in the HECOF grant agreement [1]: "A pilot testing and evaluation approach will be defined to make sure that both the technical functionality and the pedagogic aspects of HECOF technology for the two pilot universities are evaluated. In this regard KPIs will be defined for each of the components and integrated system. To ensure the smooth operation of the pilots after deployment, procedures will be established in order to ensure that standardised methods and techniques are used for the efficient and prompt handling of all support requested by end-users. (Lead: NURO, Contributors: All partners)"

The current document builds upon the results of WP2, WP3, and is in strong collaboration with the agile development in WP4 to plan the preparation, training and evaluation of the HECOF System.

1.3 About the Project

"Higher Education Classroom Of the Future" (HECOF, ERASMUS+ GA No 101086100) initiative aims at revolutionising higher **education teaching practices and education policies** by creating systemic change. A multidisciplinary team develops and tests an innovative **personalised, adaptive** way of teaching, that exploits the digital data from students' **learning** activity **in immersive environments** and uses computational analysis techniques from data science and AI. This also necessitates the development and uptake of **safe and lawful AI**, that respects fundamental rights by providing insights on **ethical and legal issues** around the design of the system. The project focuses on the field of **Chemical Engineering**, with involvement of **students and teaching staff**, from two pilot universities. HECOF technology has a clear potential to be mainstreamed in the vocational education and training sector for employees in the chemical engineering sector. Therefore, HECOF will support the first strategic priority of the **Digital Education Action Plan** (2021-2027), the development of a high-performing digital education ecosystem, by building capacity and critical understanding in all type of education and training institutions on how to exploit the opportunities offered by digital technologies for teaching and learning at all levels and for all sectors and to develop and implement digital transformation plans of educational institutions.

HECOF follows a state-of-the-art **hybrid development methodology** [2] with Lean/UX in WP2, adaptive learning concepts [3], [4] in WP3, and SCRUM in WP4 in a phase frame defined in WP1, and refined in WP5, see section 2.

1.4 HECOF Overall Objective

The primary goal of the HECOF project is to **drive systemic change in higher education** by promoting innovation in teaching practices and national education reforms. This will be achieved by developing and testing an **innovative, personalized, and adaptive approach to teaching** that utilizes digital data from students' learning activities **in immersive environments** and incorporates computational analysis techniques from **data science and AI**.

HECOF has defined four specific objectives, while this document focuses on SO4:

- **SO1:** To design and develop instructional content and a personalized adaptive learning system in immersive learning environments with a conceptual focus on "Chemical Engineering" academic discipline
- **SO2**: To engage teaching staff and students in shaping and co-designing the learning system
- **SO3**: To foster the development and uptake of safe and lawful AI that respects fundamental rights by providing insights on ethical and legal issues around the design and ethical educational deployment of AI-based technologies for teaching and learning.
- **SO4**: ***To pilot and assess the performance of the HECOF prototype system at the EU level, in a "Chemical Engineering" real classroom setting in two pilot studies, in terms of (i) effective and adequate learning experience (completeness), (ii) perceived benefits compared to traditional pedagogical model (quality), and (iii) user experience (acceptance).***

1.5 Specific Objectives and Deliverables in WP5

WP5 addresses HECOF objective SO4 and by six specific objectives:

1) Recruit students for the pilots and setup the pilot environment.
2) Train the teaching staff and students on how to use the HECOF solution.
3) Identify the starting level of knowledge, skills of students involved in pilot tests.
4) Fully operate and test the HECOF components and architecture on piloting experiments aimed to validate the HECOF prototype solution from a usability and end-user point of view.
5) Provide feedback and recommendations for HECOF system refinement in WP4.5) To validate the HECOF prototype solution from a usability and end-user point of view.
6) Evaluate the effectiveness of the HECOF prototype solution, the potential positive and negative effects of using AI in an immersive learning environment for personalized adaptive learning from the point of view of the pilot studies' participants

T5.1 planning of WP5 will target on fulfilling all these objectives as described in this document. As **guideline for HECOF Phase 3 "Monitoring and evaluation".** This deliverable will be followed up by D5.2, and D5.3. The results of the pilot 1 and pilot 2 first user evaluation will be reported in deliverable, **D5.2 "First evaluation of pilot activities & user requirements refinement"** in M24, succeeded by **D5.3 "Final evaluation and impact assessment"** in M30 after the second evaluation. "WP4 Agile development of HECOF system" will receive D5.2 for refinement of the development. D5.3 as final resume of WP5 will be delivered to "WP6 Communication, dissemination and exploitation".

2 WP5 Structure

WP5 handles the implementation of **Phase 3: "Monitoring and evaluation"** (Month 22-Month 29) - addressing **SO4** ***"To pilot and assess the performance of the HECOF prototype system at the EU level, in a "Chemical Engineering" real classroom setting […]"***.

Based on input from **WP2 "Requirements analysis & privacy, social and ethical impact assessment"**, **WP3 "Instructional strategies and assessment design"**, and **WP4 "Agile development of HECOF system"**. The agile co-development in WP4 and WP5 will continuously improve the HECOF system and training exercises, based on MVP1, released in M22 as D4.1, with a feature freeze for **evaluation 1**. Outcome of the first evaluation will refine D2.1, and D5.1 by D5.2 to adapt the development in WP4 and prepare the final evaluation. The co-development will be continued based on the first evaluation outcome to prepare MVP2 for the final evaluation 2.

Evaluation 2 will assess the D4.2 "HECOF Integrated system- Final release", delivered in M26. The outcome of pilot 1 and 2 will be analysed and compiled into D5.3 Final evaluation and impact assessment.

HECOF piloting will be implemented at two pilot universities in the field of chemical engineering.

- Pilot 1: NTUA, chemical extraction process
- Pilot 2: POLIMI, bioreactor

2.1 Phases in HECOF

HECOF is organized in four interrelated phases (**Error! Reference source not found.**):

- Phase 1: Preparation (Month 1-Month 12) - Obj. addressed:SO1, SO2, SO3 (WP1,2,3)
- Phase 2: Implementation (Month 13-Month 26) - Obj. addressed:SO1 (WP4)
- **Phase 3: Monitoring and evaluation (Month 22-Month 29) - Obj. addressed:SO4 (WP5)**
- Phase 4: Dissemination and exploitation (Month 3-Month 30) - Obj. addressed: SO5, SO6

To enable WP5 to full fill all these objectives, T5.1 performed the piloting planning as described in this document to implement phase 3 of HECOF.

2.2 Phases of WP5

WP5 implements phase 3 "Monitoring and evaluation" and is structured in 8 sub phases:

1. **PH3.0:** Planning of methodology (WP5, T5.1 NURO) D5.1 M21
2. **PH3.1:** Preparation of pilot activities (WP5, T5.2, E5.1 & E5.2 SIMAVI)
3. **PH3.2:** Users Training (WP5, T5.3, E5.2 & E5.4 ADAPTEMY)
4. **PH3.3:** Evaluation 1 running and monitoring (WP5, T5.4 SIMAVI)
5. **PH3.4:** Analytics of the outcome and refinement of D2.1 & D5.1 by D5.2 M24 (WP5, T5.5 NURO)
6. **PH3.5:** Agile development of MVP2 (WP4, KT, all partners)
7. **PH3.6:** Evaluation 2 running and monitoring (WP5, T5.4 SIMAVI)
8. **PH3.7:** Analytics of the outcome and impact assessment by D5.3 M30 (WP5, T5.5 NURO)

Table 1 presents an overview of phase 3 as GANTT chart in week granulation, details of the sub phases are in section 5.1 of the Implementation Plan.

HECOF WP5 Time Line												
Project month	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30
Month/Year	Jul 2024	Aug 2024	Sep 2024	Okt 2024	Nov 2024	Dez 2024	Jan 2025	Feb 2025	Mrz 2025	Apr 2025	Mai 2025	Jun 2025
Quarter	Q3			Q4			Q1			Q2		
First day	01.+ 08.+ 15.+ 22.+ 29.+	05.+ 12.+ 19.+ 26.+	02.+ 09.+ 16.+ 23.+	30.+ 07.+ 14.+ 21.+ 28.+	04.+ 11.+ 18.+ 25.+	02.+ 09.+ 16.+ 23.+	30.+ 06.+ 13.+ 20.+ 27.+	03.+ 10.+ 17.+ 24.+	03.+ 10.+ 17.+ 24.+ 31.+	07.+ 14.+ 21.+ 28.+	05.+ 12.+ 19.+ 26.+	02.+ 09.+ 16.+ 23.+ 30.+
Week	W27 W28 W29 W30 W31	W32 W33 W34 W35	W36 W37 W38 W39	W40 W41 W42 W43 W44	W45 W46 W47 W48	W49 W50 W51 W52	W01 W02 W03 W04 W05	W06 W07 W08 W09	W10 W11 W12 W13 W14	W15 W16 W17 W18	W19 W20 W21 W22	W23 W24 W25 W26 W27
Phases	... Phase 2: Implementation (M13-M26) Feature freeze:											
	... Phase 4: Dissemination and exploitation (M03-M30)											
	WP5 (M19-M30, SIMAVI) Pilot testing, evaluation and impact assessment											
				Phase 3: Monitoring and evaluation (M22-29)								
Phase 3		PH3.0 Planning, T5.1		PH3.1 Preperation	PH3.2 Training	PH3.3 Eval 1	PH3.4 -> D5.2	PH3.5 Agile Development MVP2	PH3.6 Eval 2			PH3.7 Compile D5.3
Events				TBD		TBD			TBD			
Input					D4.1			D4.2				
Output			D5.1				D5.2					D5.3
Project month	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30

Project Ended

Table 1: HECOF Phases overview with a focus on WP5

2.3 Related HECOF Milestones

- MS6 (M24): First evaluation of pilot activities & user requirements refinement
- MS7 (M30): Second round of pilot activities are implemented, and the effectiveness of the proposed learning environment and user satisfaction is assessed

2.4 Events

While the HECOF piloting **preparation and training events** will be performed on the pilot sites and **two evaluations** will be performed. Additional online workshops will be organized.

- E5.1 Deployment of HECOF system and VR equipment at NTUA
- E5.2 Deployment of HECOF system and VR equipment at POLIMI
- E5.3 User training at NTUA
- E5.4 User training at POLIMI
- Evaluation 1 run by T5.4 at NTUA and POLIMI
- Evaluation 2 run by T5.4 at NTUA and POLIMI

These events will be prepared and held by the related tasks for pilot preparation, training, and running. It is recommended to perform setup and training events, E5.1 + E5.3 at NTUA and E5.2 + E5.4 at POLIMI, as combined hybrid events. **Detail planning will be performed by T5.2** "Preparation of pilot activities".

2.5 Schedule of WP5 (Timetable)

Phase / Event	Month	Responsible	Step
PH3.0	M20-M21	NURO	T5.1 Planning, D5.1 M21
PH3.1	M22/M23	SIMAVI	T5.2 Preparation, E5.1 + E5.2
PH3.2	M22/M23	ADAPTEMY	T5.3 Training, E5.3 + E5.4
E5.1 + E5.3	TBD	NTUA	Preparation and training event for Pilot 1
E5.2 + E5.4	TBD	POLIMI	Preparation and training event for Pilot 2
PH3.3	M23/M24	SIMAVI	T5.3 Pilot Running and Monitoring, Evaluation 1
Eval 1.1	TBD	NTUA	Evaluation 1 / Pilot 1
Eval 1.2	TBD	POLIMI	Evaluation 1 / Pilot 2
PH3.4	M24	NURO	D5.2 "First evaluation of pilot activities & user requirements refinement"
PH3.5/ PH2	M25-M26	KT	WP4 agile development of MVP2
PH3.6	M27–M29	SIMAVI	T5.3 Pilot Running and Monitoring, Evaluation 2
Eval 2.1	TBD	NTUA	Evaluation 2 / Pilot 1
Eval 2.2	TBD	POLIMI	Evaluation 2 / Pilot 2
PH3.7	M30	NURO	T5.5 Evaluation and Impact assessment, D5.3

Table 2: Piloting and Evaluation Timetable

Recommended time frames to be discussed and decided by T5.2 preparation:

- Onsite preparation and training: W44/W46 in the transition from T5.2 to T5.3
- Evaluation 1 in the frame W47-W48

3 Partners Roles and Obligations in WP5

The HECOF partners roles and obligations during the execution of the pilots are defined by this section, in order of beneficiary number.

3.1 KT – Coordinator, Technical Lead, Backend, Data Lake, and Deployment

Overall roles of KT are coordinator of HECOF (WP1, WP6), technical lead (WP4).

KT delivers the first release of the HECOF system by D4.1 as input for the pilot 1.

In WP5, T5.4 KT is the provider of the backend and data lake developed in WP4. (T4.3 – T4.7).

- Deployment of the HECOF infrastructure
- Support
- Maintenance and bug fixing
- Contribution to D5.1, D5.2 & D5.3

Findings of pilot 1 (D5.2) will be incorporated in the second development phase of WP4.

KT delivers the final release of the HECOF system by D4.2 as input for the pilot 2.

3.2 NTUA – Use Case Partner 1, Chemical Extraction Process

Use case partner for pilot 1, chemical extraction process.

- Hosting E5.1 & E5.3
- Performing evaluation 1 & 2 by integration into the teaching.
- Provide feedback to D5.2 & D5.3
- Contribution to D5.1

3.3 POLIMI – Use Case Partner 2, Bioreactor

Use case partner for pilot 2, bioreactor.

- Hosting E5.2 & E5.4
- Performing evaluation 1 & 2 by integration into the teaching.
- Provide feedback to D5.2 & D5.3
- Contribution to D5.1

3.4 NURO – XR Lab Editor and Player, Pilot Planning and Reporting

Overall role of NURO is technical partner of HECOF responsible for user requirements (WP2, D2.1, D5.2), pilot planning and reporting (D5.1, D5.3). In WP4 NURO is responsible for the VR-LAB exercise experience and integration with Adaptemy AI, and adaptive learning (T4.1) and supports API development and integration (T4.8, T4.9).

In WP5 NURO is responsible for the pilot and evaluation planning (T5.1, D5.1), and reporting. Compiling pilot 1 outcome into D5.2 as feedback to WP4 (T5.4), and pilot 1 outcome into D5.3 as feedback to WP6 (T5.5).

NURO delivers the outcome of T4.1 to the first release of the HECOF system by D4.1.

In WP5, T5.4 is the NURO provider of the VR-LAB editor and exercise experience developed in WP4. (T4.1) in cocreation with the educators from the pilot sites.

- Delivery of editor and XR player software.
- Delivery of basic XR exercises.
- Support of the teaching staff to adapt the exercise.
- Technical support.
- Maintenance and bug fixing
- Delivery of D5.1, D5.2 & D5.3

Findings of pilot 1 (D5.2) will be incorporated in the second development phase of WP4.

NURO delivers the final release of the HECOF XR components to D4.2 as input for the pilot 2.

3.5 SIMAVI – Dashboard and API, Pilot Preparation, Running and Monitoring

Overall role of SIMAVI is technical partner of HECOF responsible for piloting and evaluation implementation (WP5), In WP4 SIMAVI is responsible for the HECOF dashboard (T4.9) and integration with NURO's XR technology (T4.8, T4.9).

SIMAVI is WP5 lead and responsible for the pilot and evaluation preparation (T5.2, E5.1, E5.2) and running (T5.4).

SIMAVI delivers the outcome of T4.1 to the first release of the HECOF system by D4.1.

In WP5, T5.4, SIMAVI is provider of the dashboard and API developed and integrated in WP4 (T4.8. T4.9, T4.10).

- Preparation and implementation of E5.1, E5.2.
- Delivery of editor and XR player software.
- Delivery of basic XR exercises.
- Support of the teaching staff and students.
- SIMAVI collects the user feedback
- Maintenance and bug fixing
- Contribution to D5.1, D5.2 & D5.3.

The findings of pilot 1 (D5.2) will be incorporated in the second development phase of WP4.

SIMAVI delivers the final release of the HECOF dashboard and API to D4.2 as input for the pilot 2.

3.6 ADAPTEMY – Adaptive learning, AI, and User Training

The overall role of ADAPTEMY is as a technical partner of HECOF responsible for learning design for AI-based adaptive learning (WP3), and AI driven adaptive learning technologies (WP4), Moreover, in WP4, Adaptemy is responsible for HECOF's AI-based Adaptive Learning Component that will integrate and configure the Adaptemy AI Adaptive Learning Engine as per HECOF's Learning Design (T4.2), co-development with KT's of the HECOF ML and data analytics modules (T4.3, T4.4, T4.5) and the integration with NURO's XR technology.

In WP5, ADAPTEMY is responsible for the user training (T5.3, E5.2, E5.4).

ADAPTEMY delivers the outcome of T4.2 to the first release of the HECOF system by D4.1.

In WP5, T5.4 ADAPTEMY is the provider of the adaptive learning technology developed in WP4. (T4.1) based on the learning design (WP3).

- Preparation and implementation of E5.2, E5.4.
- Delivery of AI and adaptive learning components.
- Support of the teaching staff.
- Technical support.
- Maintenance and bug fixing
- Contribution to D5.1, D5.2 & D5.3

Findings of pilot 1 (D5.2) will be incorporated into the second development phase of WP4.

ADAPTEMY delivers the final release of the HECOF adaptive learning modules to D4.2 as input for the pilot 2.

4 Evaluation and Monitoring Methodology

4.1 Theoretical Approach

The approach for HECOF evaluation employs a mixed-methods approach, combining quantitative metrics from system performance and learning analytics with qualitative feedback from users. The methodology integrates current AI-adaptive learning and VR training research to assess the system's impact [3], [4], [5].

Evaluation dimensions:

- **Technical functionality**: system uptime, API success rate, response time, VR performance
- **System performance**: system accuracy performance
- **Pedagogical impact**: learning improvements and effectiveness
- **Satisfaction and perceived usefulness**: student and teacher experience
- **Usability Evaluation:** learning experience in learning loops, VR and overall system usability
- **Social Impact and Presence**: evaluation through interviews and surveys

4.2 Technical functionality

The technical functionality of the AI engine and VR experience play critical roles in ensuring smooth, uninterrupted learning experiences for students and educators. One of the key aspects is **system uptime**, which refers to the percentage of time the system is operational and accessible. Another crucial metric is the **API success rate**, which tracks the percentage of successful data requests made to the AI engine. In terms of **response times**, the goal is to keep a low latency (i.e., <1s), For the VR experience key metrics are **start time** for the VR exercise (i.e. < 3s) and **frame rate in VR** also the previous described response time of the AI API. VR start time and AI response time providing users with near-instant feedback and ensuring that adaptive learning paths adjust in real-time, maintaining optimal performance across various usage scenarios is essential to guarantee that **students experience seamless, personalised learning**. For the usage of head mounted VR devices a high frame rate (i.e. >60fps in VR, >30fps on desktop) is mandatory to have a **comfortable VR experience** and avoid the occurrence of VR sickness.

4.3 System Performance

The accuracy of the Adaptemy AI engine is a key measure of its effectiveness in delivering personalised and adaptive learning experiences. **System accuracy** refers to the AI's ability to correctly predict student outcome to assessment questions and further on to make predictions about learning needs. This is achieved by building a learner model based on evidence from the learner interactions.

To measure system accuracy effectively, we will focus on students who have provided sufficient initial evidence, such as completing early assessments. This approach helps mitigate the cold start problem, which occurs when the AI system lacks enough data to make accurate predictions or personalise learning paths effectively. By waiting for students to complete some initial work, we ensure that the AI has gathered enough meaningful data to make informed decisions. High accuracy directly impacts recommendations, fostering a more personalised and efficient learning journey.

4.4 Pedagogical Impact

The pedagogical impact of the HECOF AI and VR experience will be measured through key metrics that track learning improvements and overall effectiveness. One of the primary indicators of learning effectiveness will be the **learning gain per session per concept**, which measures how much students improve in their understanding of specific concepts after each learning session. This will be closely monitored through **learning analytics**, which provide insights into student progress and mastery of

concepts, allowing us to track incremental improvements over time. Additionally, **pre- and post-tests** will be used to quantify learning outcomes, measuring the difference in student performance before and after engaging within the pilot. Other important metrics include the module **completion rate,** and **concept mastery rates**. These measures will provide a comprehensive view of the effectiveness of the AI-driven adaptive learning approach in enhancing student outcomes.

4.5 Satisfaction and Perceived Usefulness

The satisfaction and perceived usefulness of the HECOF system are essential for ensuring both students and teachers have a positive experience with the system. This dimension evaluates the **perceived usefulness**, where students and teachers evaluate how beneficial the AI-driven personalization and VR simulated exercises are in achieving their learning and teaching objectives. Lastly, the evaluation will focus on **overall user satisfaction**, evaluating how satisfied students and teachers are with the platform's ability to enhance their learning and teaching experiences without overwhelming them with complexity or technical difficulties. Furthermore, this dimension will evaluate the HECOF prototype solution through the lenses of the **potential positive and negative effects** of using AI in an immersive learning environment for personalised adaptive learning from the point of view of the pilot students' and teachers' participants.

4.6 Usability Evaluation

The usability evaluation of the HECOF system will focus on how effectively it supports seamless learning experiences through adaptive learning loops, the integration of **virtual reality (VR)**, and overall system usability. In the context of **learning loops**, the goal is for students to progress through these loops without disruptions. The inclusion of **VR** adds another dimension, offering immersive, interactive experiences that make learning more engaging. However, the usability of VR components will be evaluated based on their ease of use and whether they enhance, rather than complicate, the learning process. Another aspect for VR experience is the **well-being in VR** [5] and the usability of the flat 3D desktop version as fallback. Lastly, the system's **overall usability**—including navigation, and ease of use —will be assessed to ensure that both students and teachers can use the platform effectively without extensive training or technical issues. Furthermore, this dimension will test the HECOF AI, VR and data analytics components aiming to validate the HECOF prototype solution from a usability and end-user point of view. Students and teachers will provide **feedback and recommendations** for HECOF **system refinement**.

4.7 Social Impact and Presence

In AI-adaptive learning systems without direct collaborative features, evaluating **social impact** and **social presence** focuses on how the system fosters interaction between students, teachers, and the platform itself. Metrics such as **teacher-student interaction frequency** and **peer engagement levels** can reveal the system's ability to promote social learning and connection. Surveys on **social presence** and **perceived isolation** provide insights into whether students feel supported or disconnected during their learning experience. Tracking these dimensions ensures that, even without built-in collaboration, the system encourages meaningful interaction and reduces feelings of isolation through its dashboards, human computer interfaces and Virtual Tutor. While the requirements analysis a **multiuser experience in VR** was rejected by students and educators to avoid complex time coordination effort. After evaluation 1 this option for social interaction will be reviewed and discussed.

4.8 Monitoring

Student qualitative feedback and **teachers' observations** combined with additional open-ended one-on-one **interview data** will be collected for each of the two pilot studies. Usage of additional or alternative tools such as online surveys will be discussed and decided in the preparation.

Technical partners will closely monitor throughout the pilot the **operation of the integrated system** to assure maximum system operability and to locate possible deficiencies that should be considered. After the authentication to the platform, different **details and metrics** will be stored as the user follows specific courses. This data will be available during the participation of the students to the courses and also afterwards for detailed analysis. The visual interface from the platform and the Swagger based API will help with the centralization and monitoring of all relevant details about the users.

The **consent from the participant** will also be used for the centralisation of the statistical data about the users' performance.

5 Implementation Plan

5.1 Phases of WP5

WP5 implements phase 3 "Monitoring and evaluation" in 8 sub phases:

- **PH3.0:** Planning of methodology (WP5, T5.1 NURO) D5.1 M21
- **PH3.1:** Preparation of pilot activities (WP5, T5.2, E5.1 & E5.2 SIMAVI)
- **PH3.2:** Users Training (WP5, T5.3, E5.2 & E5.4 ADAPTEMY)
- **PH3.3:** Evaluation 1 running and monitoring (WP5, T5.4 SIMAVI)
- **PH3.4:** Analytics of the outcome and refinement of D2.1 & D5.1 by D5.2 M24 (WP5, T5.5 NURO)
- **PH3.5:** Agile development of MVP2
- **PH3.6:** Evaluation 2 running and monitoring (WP5, T5.4 SIMAVI)
- **PH3.7:** Analytics of the outcome and impact assessment by D5.3 M30 (WP5, T5.5 NURO)

5.1.0 Phase 3.0: Planning of Pilot Monitoring and Evaluation Methodology

PH3.0 is the **initial planning** of Phase 3. Phase 3 will start by M22 with delivery of this report. This preliminary phase plans the methodology for initialisation of Phase 3 with a scaffolding for the **implementation schedule**. In the agile basis of HECOF implementation, adaptation and refinement can be performed in the preparation and user training sub phases. In this phase all HECOF partners participated and contributed related to their roles, responsibilities, and tasks in the project.

5.1.1 Phase 3.1: Preparation of Pilot Activities

HECOF piloting will be prepared in this phase and **detailed planning of the evaluation 1** will be performed. This phase ends with the events E5.1 and E5.2 and the **deployment of HECOF MVP1** as **"D4.1: Integrated system first release".** This proof-of-concept demonstrator will represent the HECOF system in an early beta state where all components are integrated, and the relevant major features are implemented.

5.1.2 Phase 3.2: Users Training

This phase starts with **on-site user training for students and educators**, performed in E5.3 and E5.4. PH3.2 will focus on the educator user interfaces for refinement of the training and VR exercises and update of MVP1 to prepare the evaluation in PH3.3. While this phase additional online workshops for the co-development of the VR exercises will be performed. The details of the suggested course structure can be found in section 5.2.2 and will be refined in T5.2.

5.1.3 Phase 3.3: Evaluation 1 Running and Monitoring

Evaluation 1 will be conducted at both pilot sites with a focus on the usage of the HECOF system in the teaching activities by students and teachers, scheduled with respect to the university's dependencies. For each pilot a group of 10 students will participate. Evaluation runtime will be at least one week. WP4 co-development will have a feature freeze one week before the evaluation starts. **While the evaluation feedback and data will be collected to initiate PH3.4.**

SIMAVI will be in charge of the deployment, support and monitoring of the proposed solution to the pilots (NTUA and POLIMI). Specifically, a dashboard will be developed to receive information from the APIs related to the tools developed by partners (e.g., using Swagger to communicate with the tool developed by Adaptemy). The information will be then processed and the dashboard will be able to deliver aggregated data for the pilots (e.g., type of users, level of involvement, list of suggestions, etc.). As an overall assessment, the activity is based on the monitoring of the implementation and usage of the tools with a focus on generating meaningful feedback and information consolidation.

5.1.4 Phase 3.4: Analytics of the Outcome and Refinement of Requirements

Outcome from PH3.2 educators feedback and PH3.3 students feedback will be discussed, analysed, and compiled into **D5.2 "First evaluation of pilot activities & user requirements refinement"**, delivered in M24. D5.2 is the refinement of "D2.1 User Requirements and Functional Specifications", and this document D5.1 to enable the agile development of MVP2 in phase 3.5. D5.2 will include the detailed planning for evaluation 2. Necessary meetings will be held online. **With the end of this phase, milestone MS6 "First evaluation of pilot activities & user requirements refinement" is achieved.**

5.1.5 Phase 3.5: Agile Development of MVP2

Related to phase 2 "Implementation", WP4 will continue the **agile co-development** based on D5.2. During this phase, the HECOF system will be finalised, and training and exercises will be also refined in collaboration with the educators of the pilot partners.

This phase will end with the deployment of "D4.2: Integrated system - Final release", the final and feature complete prototype of the HECOF system in **M26 to enable the final evaluation in PH3.6.**

5.1.6 Phase 3.6: Evaluation 2 Running and Monitoring

In a **first step, to prepare the final evaluation**, training and **exercises will be finalised** by the educators of the pilot partners in collaboration with the technical partners. Evaluation 2 will be implemented at both pilot sites by integration in the teaching activities with a runtime of at least one week.

Objective of this evaluation is to collect feedback and data to enable the final phase PH3.7.

SIMAVI will implement the same approach in both evaluation phases, with a more detailed and tailored approach during the second one, due to prior experience and also increased availability of the tools.

5.1.7 Phase 3.7: Analytics of the Outcome and Impact Assessment

The **last phase of WP5** will analyse and summarise the **piloting outcome**. At the end of the pilot activities. T5.5 will implement and apply an impact assessment survey amongst the users (students and educators) of the system. Findings about user satisfaction and system performance of the HECOF system will be reported with **D5.3 "Final evaluation and impact assessment"**. This report will provide insights to technical aspects, pedagogical impact, satisfaction, perceived usefulness, usability, and social impact for the HECOF approach of an novel AI driven adaptive and immersive learning environment.

Results of the piloting will be presented and delivered with the report D5.3 "Final evaluation and impact assessment" in M30 to close the activities of WP5.

5.2 Preparation and User Training Events

For a sustainable implementation and optimised organisation, it was recommended to combine the pilot onsite events for "Deployment of HECOF system and VR equipment" and "User training" in the transition from phase 3.1 preparation to 3.2 training as hybrid events embedded in online workshops.

- For Pilot 1: E5.1+E5.3 "Deployment and User traing for the HECOF System at NTUA"
- For Pilot 2: E5.2+E5.4 "Deployment and User traing for the HECOF System at POLIMI"

These events will be followed up by the customization of the HECOF System for the evaluation 1 by focusing the agile co-development on adapting the functionality, training, and exercise configuration of the HECOF system.

5.2.1 Preparation

In the Phase 3.1 preparation, the concrete implementation planning for user training and evaluation 1 will be elaborated in several online events. Students at each partner university will be recruited (by NTUA and POLIMI) for the activities specific to the pilots. T5.2 will be focused on obtaining the signed consent from the participants in the pilot studies, assessment of the recruited student's level of knowledge/skills/attitudes, and special needs/requirements (student profile).

5.2.2 Combined Events for Deployment and User Training

This is the proposed structure of the training course and will be refined in the preparation phase.

The user training consists of 7 modules. Module 1, 2, 3 and 4 could be online sessions and Module 5, 6, 7 should be held in-presence.

Module 1: Introduction to the HECOF System and Pedagogical Foundations (30 minutes)

- **Objective**: Provide participants with an understanding of the HECOF system's goals, AI-adaptive learning, and the pedagogical principles behind it.
- **Content**:
    - Overview of HECOF's capabilities and its integration in higher education.
    - Pedagogical foundations of the HECOF system
    - Overview of AI-adaptive learning
    - AI's role in adaptive learning through the Adaptemy AI Engine
    - Expected learning outcomes and improvements.

Module 2: Configuration of the Adaptemy AI Engine According to Learning Design (1 hour)

- **Objective**: Explain how the AI engine is customised according to the specific learning design of the pilot.
- **Content**:
    - Overview of how the Adaptemy AI engine was configured in accordance with the learning design (i.e., learning design configuration for each loop in Thoth)
    - Explanation on how the system uses data (i.e., evidence from student learning) to build a learner model and then to further adjust learning paths dynamically
    - Learning analytics and their application to real-time teaching strategies

Module 3: Smart Learning Analytics and Data Collection (30 minutes)

- **Objective**: Explain how the Adaptemy AI engine uses data to measure system performance and effectiveness.
- **Content**:
    - Overview of smart learning analytics (and performance metrics) for AI-enabled adaptive learning
    - Data collection processes and real-time feedback
    - Ethical considerations and data privacy in educational technology

Module 4: VR Exercise Editor Introduction (2 hour)

- **Objective**: Explain how educators can create an VR exercise with the NURO XR Editor.
- **Content**:
    - Overview of the XR Editor
    - 3D Editor - creation of the virtual experience
    - Node Editor - configuration of functionality

Module 5: Learning Experience Design and Demo (2 hours)

- **Objective**: Demonstrate how the HECOF system tailors learning experiences and how the AI engine adapts based on user interaction.
- **Content**:
    - Detailed walk-through of the learning experiences integrated into the system and hands-on demo of the learning loops in action, showing how it adapts based on real-time student interactions
    - Explanation of how the system integrates VR technology and its benefits for learning
    - Explanation of how the system integrates GenAI technology in Think-Pair-Share and its benefits for learning

Module 6: Hands-On Practice with HECOF (30 minutes)

- **Objective:** Provide a concise, interactive session where participants explore basic functionalities of the HECOF system
- **Content:**
    - Simplified interactive demo: Teachers and students explore core functions of the HECOF platform, including navigating the user interface, engaging in learning experiences
    - Brief Q&A to resolve any immediate queries about using the system

Module 7: Q&A and Feedback Session (30 minutes)

- **Objective:** Allow participants to ask questions and provide feedback on the training session and on the HECOF system.
- **Content:**
    - Open discussion to address any remaining concerns or doubts
    - Feedback gathering on user experience with the HECOF system

Duration

The entire course will be **7 hours**, broken down as follows:

- **Module 1**: 30 minutes
- **Module 2**: 1 hour
- **Module 3**: 30 minutes
- **Module 4**: 2 hours
- **Module 5**: 2 hours
- **Module 6**: 30 minutes
- **Module 7**: 30 minutes

5.3 Evaluation 1

Objective of Evaluation 1 is to gather user **feedback for the agile development** and collect performance data from the HECOF system. Evaluation 1 will be based on D4.1 "HECOF first Minimum Viable Product (MVP)", released in M22 with customizations performed in the preparation and training phase. The detailed planning for evaluation 1 will be elaborated in T5.2 preparation of pilot activities.

Evaluation 1 will be **conducted at both pilot sites** with a focus on the usage of the HECOF system in the teaching activities by students and teachers. For each pilot a group of 10 students will participate. Evaluation runtime will be at least one week. WP4 co-development will have a feature freeze one week before the evaluation starts.

5.4 Evaluation 2

Objective of evaluation 2 is to assess the outcome of HECOF and collect performance data from the HECOF system. Evaluation 2 will be based on D4.2 "HECOF final Minimum Viable Product (MVP)", released in M26. This is a brief planning for Evaluation 2, in the agile approach of HECOF, detailed planning will be elaborated in phase 3.4 and presented in D5.2.

In a first step, to prepare the final evaluation, training and exercises will be finalised by the educators of the pilot partners in collaboration with the technical partners. Evaluation 2 at both pilot sites with integration in the teaching activities with a runtime of one week.

The outcome of HECOF piloting will be analysed and summarised in D5.3 as described in section **Error! Reference source not found.** and 5.1.7.

6 Conclusion and Future Work

This report discussed and described the initial planning for the pilots monitoring and evaluation methodology to initiate the phase 3 "Monitoring and evaluation" of HECOF implemented by WP5 "Pilot testing, evaluation and impact assessment". Phase 3 was structured in 8 subphases with a scaffold for the timeline.

The next **Phase 3.1: Preparation of Pilot Activities** will refine this plan in the agile philosophy of HECOF with detailed planning and implementation of activities for deployment, training, and evaluation preparation. This phase ends with the **deployment of D4.1 the first version of the HECOF system**, elaborated by WP4 the agile development of HECOF. **Phase 3.2: Users Training** will facilitate the implementation of the first evaluation by co-creation of the **exercises and introduction** of the HECOF system to the pilot users. While this phase updates to HECOF systems will be performed. **Phase 3.3: Evaluation 1 Running and Monitoring** will be performed at both pilot sites with integration of HECOF into teaching activities. After the first evaluation **Phase 3.4: Analytics of the Outcome and Refinement of Requirements** takes the gathered data and feedback to analyse it and deliver "D5.2 First evaluation of pilot activities & user requirements refinement ", delivered in M24. D5.2 is the refinement of "D2.1 User Requirements and Functional Specifications ", and this document D5.1 to support the agile development of MVP2 in **Phase 3.5: Agile Development of MVP2.** D5.2 will include the detailed planning for evaluation 2. **Milestone MS6 "First evaluation of pilot activities & user requirements refinement" is achieved with the deliverable D5.2.** WP4 the agile development of HECOF will finish in M26 with delivering the final version of the HECOF system, this initiates **Phase 3.6: Evaluation 2 Running and Monitoring.** First step will be the update of the exercises and additional online training when needed. Detail planning for the second evaluation will be refined and described in D5.2 at M24. The second evaluation will be conducted at both pilot sites with integration of HECOF into teaching activities. In the final **Phase 3.7: Analytics of the Outcome and Impact Assessment** the outcome of WP5 will be summarised and compiled into **"D5.3 Final evaluation and impact assessment" in M30** to close the activities of WP5 and report about the assessment of the proposed learning environments effectiveness and user satisfaction. This will **achieve milestone MS7 "Second round of pilot activities are implemented"** and support WP1 "Project management and coordination" and WP6 "Communication, dissemination and exploitation" to finalise the project.

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