Enhance
Maintenance - Production - Quality

619130-EPP-1-2020-1-FR-EPPKA2-CBHE-JP

Selection: 2020

KA2 – Cooperation for innovation and the exchange of good practices –
Capacity Building in the field of Higher Education

strENgtHening skills and training expertise for TunisiAN and MorocCan transition to industry 4.0 Era / ENHANCE

D2.6 Reports on the conducted training rounds

Deliverable Identifier	D2.6
Deliverable Date	M40 – 14/05/2024
Deliverable Version	V 1.4 - 2024
Deliverable Leader	UIT
Deliverable participants	All
Dissemination Level	Public

Document Control Page

Title	Reports on the conducted training rounds
Version	V1.4 - 2024
Deliverable number	D2.6
Work-Package	WP2
Status	☐ Draft ☐ Under Review ☐ Under Update ☐ Accepted by the coordinator ☒ Submitted to the commission
Authors	Laila EL ABBADI (UIT) / Youssef ROCHDI (UIT)
Contributors	All partners
Peer Reviewers 1:	Nejib Moalla (ULL)
Assigned Date	18/12/2023
Received Date	20/12/2023
Peer Reviewers 2:	Sabeur ElKosantini (UCAR)
Assigned Date	20/12/2023
Received Date	23/12/2023
Date of Delivery	14/06/2024
Dissemination level	☒ Public ☐ Confidential, only for ENHANCE Consortium (including EC) ☐ EU-Restricted

Version History

Version	Date	Description	Edited by
1.0		Initial Version	Laila El Abbadi
1.1		Draft for Consortium sharing	Laila El Abbadi Youssef ROCHDI
1.2		Final Draft with integration of comments from reviewers	Laila El Abbadi Youssef ROCHDI
1.3		Final Version	Youssef ROCHDI
1.4		Submitted to the commission	Nejib Moalla

Executive Summary

As a capacity building in high education project enhance focuses mainly on developing a set of training activities which will be used to train the trainers of the involved partner country High Education Institutes (HEI), and groups of industrial representatives. This deliverable reports on the conducted training rounds by giving the scheduling of training sessions and the collected data related to each session. For each training trainer session or training industrial staff session, it reports the selected training activities and statistics about trainees. It highlights the impact of this training session in the training activities continuous improvement and adoption process. By statistical analysis of the collected data, it estimates the global key indicators of the project. It also reports on two administrative training sessions. Although the training sessions were not targeting training students, a group of students were selected to attend training industrial staff sessions.

Table of contents

Table of figures

Table of Tables

1. Introduction

1.1. Purpose of the document

As a capacity building project in higher education (CBHE), Enhance targets the major players in the transition to industry 4.0: industrial staff (main and direct actor in the short term), trainers (indirect actor in the long term) and students (medium-term future actor).

The instrument used by the ENHANCE project to act on its three stakeholders (Industrial staff, trainers, and students) are the training activities (TA) developed as part of this project. These activities are intended to fill the gap between the requirements of industry 4.0 and the current state at the industrial level in Morocco and Tunisia. They have been used to train trainers and adopted by the 8 targeted training programs in partner higher education institutes, as described by the deliverable D1.5, but also to train industrial staff and students.

This deliverable (D2.6), is a report on the training sessions organized by the Moroccan and Tunisian partners for the trainers, industrial staff and administrative staff. Each partner organized two training sessions, the first one for the trainers and the second one for the industrial staff. In addition, one administrative staff training session per PC was organized. Some selected students from the involved PC-HEI are invited to attend training industrial staff sessions, without being the main target.

1.2. Reference documents

Deliverable D 1.5. Report on the training of HE staff**.**
Deliverable D 3.3 Quality Audit Reports

1.3. Applicability

NA.

1.4. Definitions

In this section, we recall some useful definitions from D1.5, which will used in the following sections. There are three pilots called:

- Pilot 1: for topic Maintenance 4.0.

- Pilot 2: for topic Production 4.0.

- Pilot 3: for topic Quality 4.0.

Each pilot contains two courses and one use case. Each course and each use case is a set of up to five training activities. Each training activity is split in tasks. Task is an elementary training unit.

In the remainder of this document, the following notation will be adopted:

Act X.Y is a training activity of a course, while Act U X.Y is a training activity of use case (when X and Y are digits).

1.5. Structure of the document

The document is structured in 8 sections and an Appendix. After the introduction section, section 2 gives a project overview. Section 3 describes the organisation of training trainers' sessions round and training industrial staff / students' sessions round. Section 4 shows the importance of these training trainers' sessions in training activities adoption by the partners and the definition of the project KPIs.

Section 5 is dedicated to Training trainers session round and its results analysis. Section 6 is dedicated to Training Industrial staff / Student sessions round and its result analysis. Section 7 describes the training administrative staff workshops. Section 8 gives some conclusions of these training sessions. Appendix 1 shows the evaluation form used in training trainers sessions.

1.6. List of acronyms

MPQ-4.0— Maintenance, production and quality in the era of industry 4.0.
HEI — High Education Institutes
M&T- HEIs — Moroccan and Tunisian High Education Institutions partner
CTA — Course Training Activity: is one component of a course according to definitions above.
UTA — Use case Training Activity: each use case is split in several training activity.
UIT — Ibn Tofail university Morocco
IIT — International Institute of Technology
UCAR — University of Carthage Tunisia
ECC — Ecole centrale Casablanca Morocco
TA — Training activity
TT — Training trainers
TIS — training Industrial staff and students
TAS — Training administrative staff

2. ENHANCE project overview

ENHANCE – strENgtHening skills and training expertise for TunisiAN and MoroCCan transition to industry 4.0 Era – is an Erasmus Plus project founded under the KA2 Cooperation for innovation and the exchange of good practices (Capacity Building in the field of Higher Education) programme by the European Commission under Grant Agreement N° 619130, to be conducted in the period January 2021 until January 2024. It engages 7 partners from 5 countries with a total budget of 779k€. Further information can be found at http://eplus-enhance.eu/.

The emergence of industry 4.0 concepts and applications brings new paradigms impacting all the industrial business domains when they need to conduct successful digital transformations or increase workshops connectivity. The evolution of Maintenance, Production and Quality Engineering (MPQ 4.0) represents the main application domains where Industry 4.0 produces effective beneficial results.
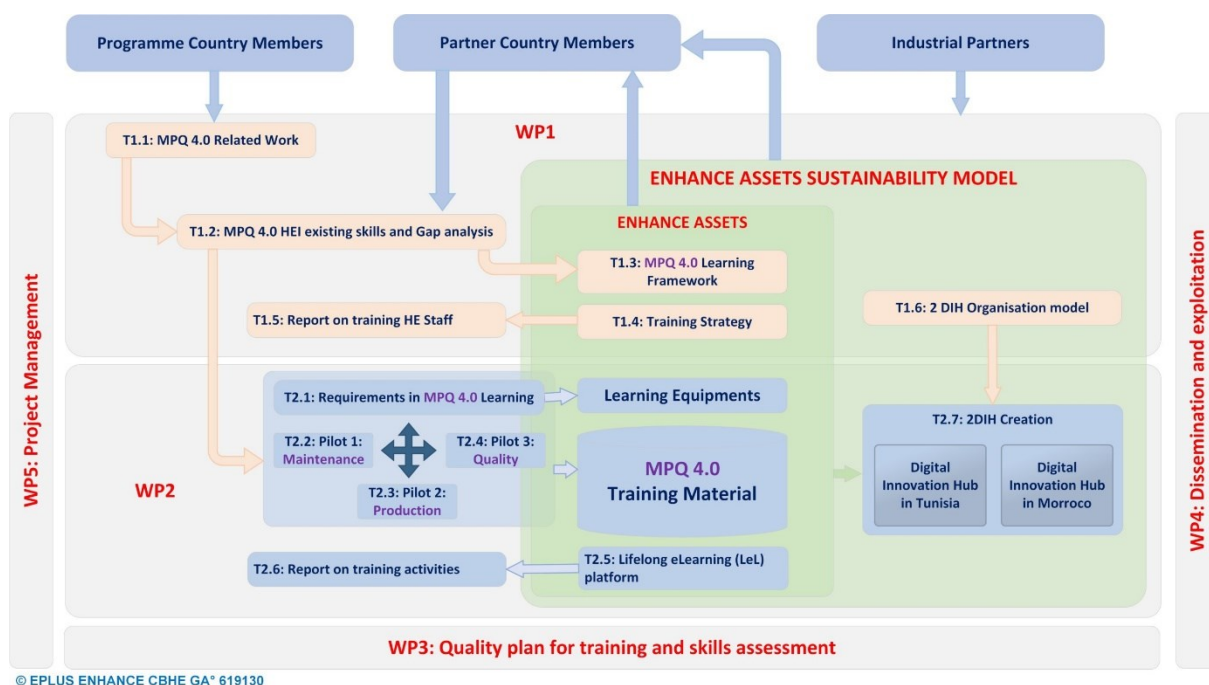
Figure 1: ENHANCE project organization

The ENHANCE project focuses on building new MPQ training capacities at Higher Education Institutions (HEI) in Tunisia and Morocco to establish interactions between the following stakeholders (Figure 1):

- European universities and research institutions (from France, Germany and Portugal) confirmed MPQ 4.0 competencies, training materials, collaborative research projects, full operational Digital Innovation Hubs (DIH), technology transfer experiences, etc.
- Partner country universities (from Tunisia and Morocco) with teaching and training activities in MPQ and existing connections with their local industrial partners.

The ENHANCE project will create several outputs and two primary tangible outcomes:

- New MPQ 4.0 equipment and training materials developed in connection with the existing training programmes and consolidated through three industrial pilots. The new material will be used to train the trainers and the students in the different partner country universities.

- Two DIHs, one in Tunisia and one in Morocco to sustain the project outcomes through their reuse for training in industry.

ENHANCE aims to become the reference model for creating effective and sustainable training material for MPQ 4.0 in both partner countries with content approved by academia and industry.

This document is developed as part of the ENHANCE project.

3. Training sessions organization

The ENHANCE project's methodology covers the full lifecycle of training activities development. The methodology starts with analysing the state of the art in MPQ-4.0. Then, industrial workshops were organized, both in Morocco and in Tunisia, to estimate the gap to MPQ-4.0: A panel of industrial representatives of Moroccan and Tunisian industrial staff was invited to provide their needs through dedicated surveys. Furthermore, the eight targeted HEI's programs were analysed to identify possible improvement actions (see D1.5). The collected information was analysed to influence the content development process, using a PDCA process described in Figure 2.
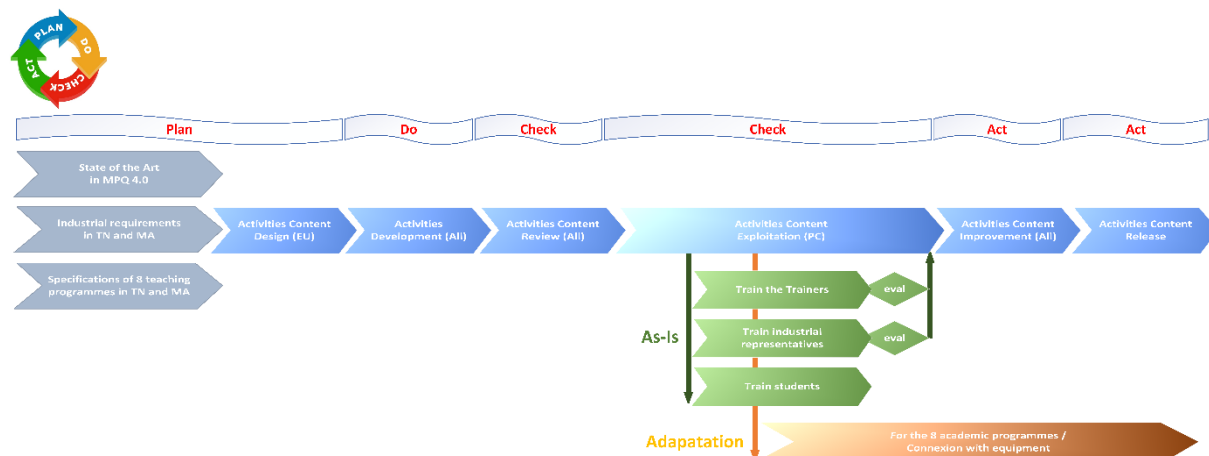
Figure 2: ENHANCE training activities development methodology

The training sessions with the partner universities in Tunisia and Morocco were planned and conducted to evaluate the developed training activities with trainers (HEI staff), industrial staff and students. After each training session, trainees' feedback are collected via **an anonymous Evaluation form** (Appendix 1). This evaluation form targets teen criteria, covering mainly the relevance of the training activity content, in respect to MPQ 4.0 exigence, and the capacity to reuse it.

It is important to note here that several training activities were used at least to time in the organised training sessions. In addition, the feedback came from three types of trainees: HEI's staff (mainly trainers which are involved in target programmes), students (in targeted programmes) and Industrial staff from two industrial contexts (Tunisia and Morocco). This process certainly allows to improve the quality/adaptability of the developed training activities before their final adoption by the targeted HEI's programmes.

3.1. Round of Training trainers' sessions

According to the deliverable D1.5, the developed training activities should/could be used, by HEI's staff, to update/ extent existing courses in HEI's programmes, or to create new ones, depending on HEI's need. So, after the development of training activities, their review by the members of consortium, during a series of plenary/remote meeting, the first round of training trainers' sessions was conducted by two partners: IIT-Sfax, Tunisia and UIT-Kenitra, Morocco. Then a second round of training the trainers session was conducted by two other partners: UCAR-Tunis, Tunisia and ECC-Casablanca,

Co-funded by the
Erasmus+ Programme
of the European Union

Enhance
Maintenance - Production - Quality

Morocco. The scheduling of these training sessions, the topics (Pilots) they considered and the number of targeted trainers are given by Table 1. Each trainers training (TT) session was scheduled on two weeks (10 working days), and it targeted a set of activities selected by the PC-HEI who organised the training session. This selection process was mainly based on the interest of the PC-HEI hosting the TT session in integrating some training activities in the existing courses it provides or those that it will be created the following criteria. This depends on:

- the TA in which the trainers to train were interested: let us recall here that the PC-HEIs involved in the project have different training programmes with different objectives and different evaluated gaps in respect of the industry 4.0 requirements. Furthermore, each PC-HEI has not the total freedom to update everything in its involved programmes.
- the priority given to each training activity by this PC-HEI through its impact on the programmes: some TA can be immediately adopted and integrated into the existing courses, by the PC-HEI, and others can be used to create new courses/programmes in the future academic years and submitted to the process of accreditation by the High Education Ministry.
- the availability of the trainers to train: the available trainers interested in training in MPQ-4.0, have participated in the TA selection process.
- the acquired equipment by this PC-HEI: each PC-HEI has chosen some equipment to use for practical training activities, so he chose TA activities linked to this equipment.
- the level of maturity of the TAs content at the training session date: not all the TAs are developed at the same time and the needed efforts to do that are not the same. Hence, the contents of the TAs were not always at the same level of maturity at the training session date.
- the fact that each TA must be used at least one time in trainers training session, to get feedback about each TA.

According to the project quality management process described by deliverable D3.3, the selected MPQ-4.0 training activities have been developed by using the PDCA approach, with continuous improvements through a series of plenary and remote meetings. Since these activities will be used at the end of the project by the PC-HEI trainers to update the PC-HEIs programmes, it was important to train these trainers using the MPQ-4.0 training activities for which they were interested first. Then using the expectations and feedback of these trainers, the training activities were improved to increase their adoption by the involved trainers. The main idea here is that more the people participate in the development process more they will be engaged.

Table 1: Scheduling of the training trainers' sessions

Date	Institute(s) - Location	Topics	Number of trainers (target)
16-27/05/2022	IIT- Sfax, Tunisa	Production & Quality	5 to 10
18-30/07/2022	UIT - Kenitra Morocco	Quality & Maintenance	5 to 10
12-23/12/2022	UCAR -Tunis, Tunisia	Quality & Production	5 to 10
13-24/03/2023	ECC- Casablanca, Morocco	Maintenance & Quality	5 to 10
		Total of trainers	20 to 40

The detailed programmes of all of training trainers' session are given by Table 2 to Table 5.

Table 2: The Scheduling of the training session for trainers at IIT-Sfax Tunisia

Day	Domain	Time	Activity	activity leader
16/05/2022	Quality	9h	Sensors sensitivity analysis: digital, analogical (use case)	ULL
	Production	14h	Planning and scheduling techniques and approaches in industry 4.0 and cloud manufacturing	UIT
17/05/2022	Production	9h	Design and development of smart Production Planning/Scheduling systems and processes	UCAR - INSAT
	Production	14h	KPIs, Dashboarding and Reporting	UCAR - INSAT
18/05/2022	Maintenance	9h	Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 context	ULL
	production	14h	distributed / digital control systems (use case)	ECC
19/05/2022	Maintenance	9h	Downtime forecast and optimal maintenance planning	UNL
	Production	14h	Automated Value Stream Mapping	UCAR - INSAT
20/05/2022	Maintenance	9h	Maintenance planning and scheduling in Industry 4.0 contexts	BIBA
	Quality	14h	Non-Conformities Root Cause Analysis and Quality gates design	ULL
23/05/2022	Maintenance	9h	Industry 4.0 Asset & Maintenance Management Systems	ECC
	Production	14h	Emerging uses of smart technologies for production planning and scheduling (use case)	IIT
24/05/2022	Production	9h	Big data and predictive inventory analytics	UNL
	Quality	14h	Quality Control model design	ULL
25/05/2022		9h à 14h	Workshop Industrie 4,0	
26/05/2022	Production	9h	IoT/CPS development, integration, Interoperability, visibility, connectivity (use case)	BIBA
	Maintenance	14h	Develop/use predictive models and algorithms (use case)	ULL
27/05/2022	Production	9h	Data-driven planning/scheduling models and algorithms	IIT
	quality	14h	Business process management –VSM (Use Case)	UIT

Table 3: The Scheduling of the training session for trainers at UIT-Kenitra Morocco

Day	Time	[Domain]Activity	Activity Leader	Activity Presenter
18/07/2022	9h-12h	[M]Contributions of Smart Maintenance 4.0 to Energy Management & Energy Efficiency of Industry 4.0 Assets	ECC	Saber
	12h-12h30	Pause-Café		
	12h30-15h30	[Q]Business process management -VSM	UIT	Abdelmajid
19/07/2022	9h-12h	[P]Automated Value Stream Mapping	UCAR	Nejib
	12h-12h30	Pause-Café		
	12h30-15h30	KPIs, Dashboarding and Reporting	UCAR	Sabeur, Sonia
20/07/2022	9h-12h	[M]Maintenance planning and scheduling in Industry 4.0 contexts	BIBA	Zied / Haron
	12h-12h30	Pause-Café		
	12h30-15h30	[M]Develop/use predictive models and algorithms	ULL	Lounes
21/07/2022	9h-12h	[Q]Sensors sensitivity analysis: digital, analogical	ULL	Sabeur, Sonia & Rami, Feiza
	12h-12h30	Pause-Café		
	12h30-15h30	[P]PLM and Digital Factory to model and act the physical system	IIT	Achraf
22/07/2022	9h-12h	[Q]Non-Conformities RCA and Quality gates design	ULL	Nejib
	12h-12h30	Pause-Café		
	12h30-15h30	[P]Planning and scheduling techniques in industry 4.0 and cloud manufacturing	UIT	Laila
25/07/2022	9h-12h	[Q]QC model design	ULL	Nejib
	12h-12h30	Pause-Café		
	12h30-15h30	[P]Production Control Systems: KANBAN, (X-)CONWIP, POLCA, COPACABANA, REDUTEX, etc.	IIT	Achraf
26/07/2022	9h-12h	[Q]Prescriptive and adaptive decision	UNL	Joao / Joao / Artem
	12h-12h30	Pause-Café		
	12h30-15h30	[P]IoT/CPS development and integration	BIBA	Zied / Haron
27/07/2022	9h-12h	[M]Sensor Network design in Smart Maintenance 4.0 contexts	BIBA	Zied / Haron
	12h-12h30	Pause-Café		
	12h30-15h30	[M]Downtime forecast and optimal maintenance planning	UNL	Joao / Joao / Artem
28/07/2022	9h-12h	the usage of a zComponent from the ZDMP project (Data Acquisition or Message Bus or Monitoring and Alerting…).	UNL	Joao / Joao / Artem
	12h-12h30	Pause-Café		
	12h30-15h30	the usage of a zComponent from the ZDMP project (Data Acquisition or Message Bus or Monitoring and Alerting…).	UNL	Joao / Joao / Artem
29/07/2022	9h-12h	Emerging uses of smart technologies for production planning and scheduling (use case)	IIT	Achraf
	12h-12h30	Pause-Café		
	12h30-15h30	[P]Virtual Reality to simulate industrial process	UIT	Abdelmajid

Table 4: Scheduling of the training session for trainers at UCAR Tunis/Nabeul Tunisia

Date	Time	Place	Pilot	Activities	Leader	Faculty
12/12/2022	9 - 12	Tunis	Maintenance	Act 2.5 Industry 4.0 Asset & Maintenance Management Systems	ECC	INSAT
12/12/2022	13 - 16	Tunis	Maintenance	Act U.1.3 ML and application for maintenance	ULL	INSAT/FSEGN
13/12/2022	9 - 12	Tunis	Production	Act U.2.5 Digital control systems (DCSs)	ECC	INSAT
13/12/2022	13 - 16	Tunis	Production	Act U.2.4 Data-driven inventory management	UNL	INSAT/FSEGN
14/12/2022	9 - 12	Tunis	Maintenance	Act 1.2 Sensor Network Design in Smart Maintenance 4.0 contexts	BIBA	INSAT
14/12/2022	13 - 16	Tunis	Maintenance	Act U.1.2 Data acquisition and storage in industry 4.0	UNL	INSAT
15/12/2022	9 - 13	Tunis	Maintenance	Act 2.2: Maintenance planning and scheduling	BIBA	INSAT
			Production	Act 3.2: Planning and scheduling techniques and approaches in industry 4.0	UIT	INSAT/FSEGN
15/12/2022	14 - 17	Tunis	Production	Act 3.5: Big data and predictive inventory analytics	UNL	INSAT/FSEGN
16/12/2022	9 - 12	Tunis	Maintenance	Act 1.4 Contributions of Smart Maintenance 4.0 to Energy Management & Energy Efficiency of Industry 4.0 Assets	ECC	INSAT
19/12/2022	9 - 14	Nabeul		Workshop		
19/12/2022		Nabeul				
20/12/2022	9 - 12	Nabeul	Quality	Act 5.2: Non-Conformities RCA and Quality gates design	ULL	FSEGN
20/12/2022	13 - 16	Nabeul	Quality	Act U.3.2 Non-Conformities RCA and Quality gates design	ULL	FSEGN
21/12/2022	9 - 12	Nabeul	Production	Act 4.4: KPI, Dashboarding and data visualisation	UCAR	FSEGN
21/12/2022	13 - 16	Nabeul	Production	Act 4.2: VSM for production 4.0	UCAR	FSEGN
22/12/2022	9 - 12	Nabeul	Quality	Act U.3.3 IoT and BPM for Integrated VSM	UIT	FSEGN
22/12/2022	13 - 16	Nabeul	Quality	Act 6.3: Inspection Methods, sampling, Inspection Plan	IIT	FSEGN
23/12/2022	9 - 12	Nabeul	Maintenance	Act 2.3 Contributions of Industry 4.0 technologies to Total Productive Maintenance	ECC	FSEGN

Table 5: Scheduling of the training session for trainers at ECC-Casablanca, Morocco

Salle G117		06/03/2023	07/03/2023	08/03/2023	09/03/2023	10/03/2023
		Monday	Tuesday	Wednesday	Thursday	Friday
Morning	09h00 - 09h30	Act 3.1: Design and development of smart Production Planning/Scheduling systems (UCAR)	Act U.1.3 ML and applications for maintenance (ULL)	Act 2.2: Maintenance planning and scheduling (BIBA)	Act 1.3 Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 context (ULL)	Act 6.1: Integrated process improvement (UCAR)
	09h30 - 10h00					
	10h00 - 10h30					
	10h30 - 11h00	Break				
	11h00 - 11h30	Act 3.1: Design and development of smart Production Planning/Scheduling systems (UCAR)	Act U.1.3 ML and applications for maintenance (ULL)	Act 2.2: Maintenance planning and scheduling (BIBA)	Act 1.3 Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 context (ULL)	Act 5.5: VSM for production 4.0 (UCAR)
	11h30 - 12h00					
	12h00 - 12h30					
		Lunch				
Afternoon	13h30 - 14h00	Act 1.1 Use cases of eXtended Reality (XR) in Smart Maintenance 4.0 contexts (UIT)	Act 1.5 Sustainability Driven Smart Maintenance 4.0 (BIBA)	Act U.1.2 Data acquisition and storage in industry 4.0 (UNL)	Act U.2.1 Emerging uses of smart technologies for production planning and scheduling (IIT)	
	14h00 - 14h30					
	14h30 - 15h00					
	15h00 - 15h30	Break				
	15h30 - 16h00	Act 1.1 Use cases of eXtended Reality (XR) in Smart Maintenance 4.0 contexts (UIT)	Act 1.5 Sustainability Driven Smart Maintenance 4.0 (BIBA)	Act U.1.2 Data acquisition and storage in industry 4.0 (UNL)	Act U.2.1 Emerging uses of smart technologies for production planning and scheduling (IIT)	
	16h00 - 16h30					
	16h30 - 17h00					

Salle G117		13/03/2023	14/03/2023	15/03/2023	16/03/2023	17/03/2023
		Monday	Tuesday	Wednesday	Thursday	Friday
Morning	09h00 - 09h30	Act 1.2 Sensor Network Design in Smart Maintenance 4.0 contexts (BIBA)	Act 2.4 Downtime forecast and optimal maintenance planning (UNL)	Act 3.5: Big data and predictive inventory analytics (UNL)	Act 6.4: Prescriptive and adaptive decision for Quality Control (UNL)	WP2 Design Industrial Training sessions (ULL)
	09h30 - 10h00					
	10h00 - 10h30					
	10h30 - 11h00			Break		
	11h00 - 11h30	Act 1.2 Sensor Network Design in Smart Maintenance 4.0 contexts (BIBA)	Act 2.4 Downtime forecast and optimal maintenance planning (UNL)	Act 3.5: Big data and predictive inventory analytics (UNL)	Act 6.4: Prescriptive and adaptive decision for Quality Control (UNL)	WP5 - PMB (ULL)
	11h30 - 12h00					
	12h00 - 12h30					
		Lunch				
Afternoon	13h30 - 14h00	Act U.1.1 Real-time communication (BIBA)	Act U.1.4 KPI, Dashboarding and data visualisation (BIBA)	Act U.2.4 Data-driven inventory management (UNL)	Act U.3.5 Prescriptive and adaptive decision for Quality Control (UNL)	*Departure*
	14h00 - 14h30					
	14h30 - 15h00					
	15h00 - 15h30	Break				
	15h30 - 16h00	Act U.1.1 Real-time communication (BIBA)	Act U.1.4 KPI, Dashboarding and data visualisation (BIBA)	Act U.2.4 Data-driven inventory management (UNL)	Act U.3.5 Prescriptive and adaptive decision for Quality Control (UNL)	
	16h00 - 16h30					
	16h30 - 17h00					

Based on the feedback of the trainers trained in these conducted TT sessions, and also on the own feeling and evaluation of the trainer who presents the activity, the content of training activity was revised and improved on several iterations. Each training activity used in a training session is evaluated by trainees through an anonymous individual form. The trainees are not always the same for all training activities in one training session.

By doing so, one maximises the fact that each training activity can be challenged and evaluated by different trainees from different horizons and so to maximise the evaluation accuracy.

3.2. Round of training industrial staff/students' sessions

After the round of the training trainers' sessions, each HEI from each partner country had to organise a training session for industrial staff and a set of students. The industrial staff invited to this training session must be interested in MPQ-4.0 topics. The students were invited among those concerned by the 8 HEI programs targeted by the project, and they attended these sessions to meet industrial staff and benefit from their feedback. Therefore, these training sessions targeted mainly the industrial staff. The target number of trainees was between 5 and 10 for the industrial staff and between 17 to 20 for the students for each partner HEI. Table 6 gives the round of TIS sessions scheduling.

Table 6: The scheduled training Industrial staff/Students sessions

Date	Institute(s) - Location	Number of Industrial staff (target)	Number of students(target)
6-10/03/2023	ECC Casablanca Morocco	5 to 10	17 to 20
14-19/05/2023	UIT - Kenitra Morocco	5 to 10	17 to 20
2-5/10/2023	IIT- Sfax, Tunisa	5 to 10	17 to 20
27/11-2/12/2023	UCAR -Tunis, Tunisia	5 to 10	17 to 20
	Total of trainees	**20 to 40**	**68 to 80**

The detailed programmes of these training sessions is given by the Table 7 - Table 11.

Table 7: The scheduling of the industrial/students training session at ECC-Casablanca

	08/05/2023	09/05/2023	10/05/2023	11/05/2023	12/05/2023		
	Monday	Tuesday	Wednesday	Thursday	Friday		
09h00 - 09h30 09h30 - 10h00 10h00 - 10h30	D2.2 : Activities adaptation for the LEL	T2.7: The 2 Digital Innovation Hubs	T2.5-D2.5 : The Lifelong eLearning (LeL) platform	D5.3 Project reporting	Act 3.5 - Act U.1.2: Data analytics for inventory management (Artem Nazarenk, UNL)	Act 1.3 and Act U.1.3 : Machine Learning to predict the Remaining Useful Life (Lounes Bentaha, ULL)	Act 1.2 and Act. U. 2.3 : FischerTechnik smart factory industry 4.0 as a cyber-physical production system
10h30 - 11h00	*Break*						
11h00 - 11h30 11h30 - 12h00 12h00 - 12h30	D2.3 : Activities adaptation for the LEL	T2.7: The 2 Digital Innovation Hubs	D2.6 Reports on the conducted training rounds	D5.3 Project reporting			
	Lunch						
13h30 - 14h00 14h00 - 14h30 14h30 - 15h00	D2.4 : Activities adaptation for the LEL	T2.7-D2.7 : Define and deploy a prototype of a CC website (case of InnoTech,	D3.2 Sustainability assurance plan	T3.3-D3.3.R1: Quality Audit reports			
15h00 - 15h30	*Break*						
15h30 - 16h00 16h00 - 16h30 16h30 - 17h00	Act 4.4 : Les réseaux de neurones : de la théorie à la pratique (Sabeur Elkosantini, UCAR)	T2.7-D2.7 : Define and deploy a prototype of a CC website (INNOVANCE, INSAT-UCAR)	Act 5.2 and Act. U. 3.2 : Industry 4.0 to enhance quality control processes and quality management systems (Nejib Moalla, ULL)	T2.6 - D2.6 Reports on the conducted training rounds			

Table 8: The scheduling of the industrial/students training session at UIT-Kenitra

	15/05/2023	16/05/2023	17/05/2023	18/05/2023	19/05/2023
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
09h00 - 09h30	*Institutional Workshop about CC and DIH*	Act 4.2: VSM for production 4.0	Act 5.2: Industry 4.0 to enhance quality control processes and quality management systems (Nejib Moalla, ULL)	Act 1.1: Use cases of eXtended Reality (XR) in Smart Maintenance 4.0 contexts (Youssef Rochdi, UIT)	WP5 - PMB
09h30 - 10h00					
10h00 - 10h30					
10h30 - 11h00	*Break*				
11h00 - 11h30	*Institutional Workshop about CC and DIH*	Act 1.2 and Act. U. 2.3 : FischerTechnik smart factory industry 4.0 as a cyber-physical production system (Zied Ghrairi, BIBA)	Act 1.3 and Act U.1.3: Machine Learning to predict the Remaining Useful Life (Lounes Bentaha, ULL)	Act 1.1: Use cases of eXtended Reality (XR) in Smart Maintenance 4.0 contexts (Youssef Rochdi, UIT)	
11h30 - 12h00					
12h00 - 12h30					
	Lunch				
14h00 - 14h30	*Institutional Workshop about CC and DIH*	Act 3.5 - Act U.1.2: Data analytics for inventory management (Artem Nazarenk, UNL)	Act. U. 3.2: Industry 4.0 to enhance quality control processes and quality management systems (Badreddine Tanane, ULL)	Act 3.4: Data-driven planning/scheduling models and algorithms (Achraf Ammar, IIT)	*departure*
14h30 - 15h00					
15h00 - 15h30					
15h30 - 16h00					
16h00 - 16h30	*Break*				
16h30 - 17h00			Act 2.3 Contributions of Industry 4.0 technologies to Total Productive Maintenance (Fouad	Act U.3.3 IoT and BPM for Integrated VSM (Abdelmajid Elouadi, UIT)	
17h00 - 17h30					

Table 9: Scheduling of the industrial/students training session at IIT-Sfax

	02/10/2023	03/10/2023	04/10/2023	05/10/2023	06/10/2023
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
09h00 - 09h30		Act. 4.2: VSM for production 4.0 Rami Benhajkacem (UCAR)	Act 1.1: Use cases of eXtended Reality (XR) in industry (Youssef ROCHDI)	Act 5.2: Industry 4.0 to enhance quality control processes and quality management systems, Nejib Moalla (ULL)	WP5 - PMB (ULL)
09h30 - 10h00					
10h00 - 10h30					
10h30 - 11h00	*Break*				
11h00 - 11h30		Act4.4: Les réseaux de neurones : de la théorie à la pratique, Sabeur Elkosentini, UCAR	Act 1.1: Atelier : Use case of Augmented Reality (Youssef ROCHDI)	Act. U. 3.2: Workshop : Quality control ; ULL Nejib et TANANE Badreddine	WP5 - PMB (ULL)
11h30 - 12h00					
12h00 - 12h30					
	Lunch				
13h30 - 14h00	Act 1.3: Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 context, Lounes Bentaha, ULL	Act 1.2 and Act. U. 2.3 : FischerTechnik smart factory industry 4.0 as a cyber-physical production system, Zied Ghrairi (BIBA)	Act U.3.3: INTEGRATION DU VSM 4.0 ET IOT VIA PLATEFORME AURAQUANTIC - BPMN (Abdelmajid Elouadi)	ECC	
14h00 - 14h30					
14h30 - 15h00					
15h00 - 15h30	*Break*				*Departure*
15h30 - 16h00	Act U.1.3: ML and application for maintenance, Lounes Bentaha, ULL	Act 3.5 - Act U.1.2: Data analytics for inventory management Data-driven inventory management, NAZARENKO Artem, UNINOVA	Act 3.4: Data driven for planning/scheduling models and algorithms Achraf & Taoufik (IIT), Use case developped as a graduation project	ECC	
16h00 - 16h30					
16h30 - 17h00					

Table 10: Scheduling of the industrial/students training session at UCAR Tunis/Nabeul

	27/11/2023 Monday	28/11/2023 Tuesday	29/11/2023 Wednesday	30/11/2023 Thursday	01/12/2023 Friday
09h00 - 09h30	Presentations to introduce the Workshop : Enjeux de la Transformation digitale et stratégie marketing digitale à mettre en œuvre, Pr. Imed Zaiem, Université de Carthage, Tunisie	Act 1.1: Use cases of eXtended Reality (XR) in industry, Youssef ROCHDI, UIT	Act. U. 3.2: Workshop : Quality control, Nejib et TANANE Badreddine, ULL	Train administrative representatives in UCAR + IIT (online)	WP5 - PMB (ULL)
09h30 - 10h00					
10h00 - 10h30					
10h30 - 11h00	Break				
11h00 - 11h30	Act4.4: Les réseaux de neurones : de la théorie à la pratique, Sabeur Elkosentini, UCAR	Act 1.1: Use cases of eXtended Reality (XR) in industry, Youssef ROCHDI, UIT	Act. 4.2: VSM for production 4.0 Rami Benhajkacem, UCAR	Train administrative representatives in UCAR + IIT (online)	WP5 - PMB (ULL)
11h30 - 12h00					
12h00 - 12h30					
	Lunch				
13h30 - 14h00	Act 1.3: Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 context, Lounes Bentaha, ULL Act U.1.3: ML and application for maintenance, Lounes Bentaha, ULL	Act 5.2: Industry 4.0 to enhance quality control processes and quality management systems, Nejib Moalla, ULL	Act 1.2 and Act. U. 2.3 : FischerTechnik smart factory industry 4.0 as a cyber-physical production system, Zied Ghrairi, BIBA	T3.2 - D3.2 (Review of the sustainability assurance plan), BIBA	
14h00 - 14h30					Departure
14h30 - 15h00					
15h00 - 15h30	Break				
15h30 - 16h00	Act 3.5 - Act U.1.2: Data analytics for inventory management Data-driven inventory management, NAZARENKO Artem, UNINOVA			T3.3 - D3.3 (Review of Quality Audit Reports), ULL	
16h00 - 16h30					
16h30 - 17h00					

4. Training activities adoption assessment methodology

The evaluation process of each training activity presented in a training trainers' session is broken down into the following steps:

- Collection of post training session feedback from trainees (i.e. M&T- HEIs trainers).
- Reflection on own training and participants' feedback after the training activity.
- Identification of key improvements in the training activities carried out.

As it was set up by section 4.1 of Deliverable D3.3 (4.1 Quality audit for train the trainers sessions) the post-training session feedback is collected using:
- An Anonymous evaluation form (see Appendix 1) filled by trained trainers: they are used to measure principally:
  - the added value provided by each training activity to reduce the gap between skills initially targeted by M&T-HEIs programmes and skills that are required by industry 4.0, particularly in topics of maintenance, production, and quality.
  - the adequacy of training activity to be integrated into existing courses and use cases or to create the new ones, taking into consideration current objectives of M&T-HEIs programmes, prerequisites of students, available equipment, and the freedom level to change existing courses.
- Discussions with the trained trainers: trained trainers are actors that will relay to transmit knowledge and how-to provided by this CBHE project to learners (Students, SMEs staff, or others, e.g. new trainers), complete and update the provided training activities in the future to guaranty to ENHANCE project certain sustainability, then discussion with these trainers was beneficial to improve the developed training activities.

After this evaluation process of each training activity, presented at least in one or several TT sessions, follows a refinement/improvement process of the training activity and its adequacy to be integrated in the maximum of the existing courses or new courses extending targeted programmes.

Then to measure the impact of the developed and improved training activities the following KPIs were used:

KPIs for Enhance:
- The number of selected ENHANCE courses for each programme (partially or totally consumed)
- The number of selected ENHANCE Use case for each programme (partially or totally consumed)
- The number of selected ENHANCE activities for each programme
- The number of selected ENHANCE use cases for each programme

Co-funded by the
Erasmus+ Programme
of the European Union

KPIs for existing programmes:
- The number of impacted courses in each programme
- The total number of hours for adaptation
- The total number of hours for extension

KPIs for Activities:
- The number of Act /Act U per pilot
- The number of activities for extension for each programme.
- The number of activities for adaptation for each programme

The obtained results are described in detail and analysed for each HEI partner, in the following section.

5. Results of training trainers' sessions analysis

5.1. IIT-Sfax training trainers' session

The Figure 3 shows the KPIs used for the assessment of the IIT training trainer session. These KPIs show that IIT provides more hours for adaptation for its BSc program than hours of extension. For the IIT, the exploitation period starts from 2022/2023 academic year.
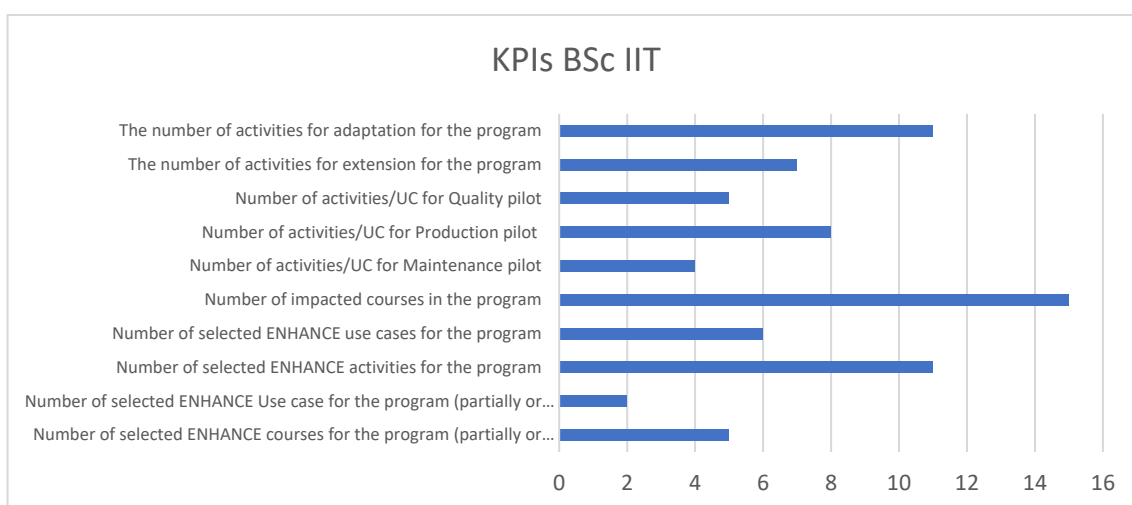

Figure 3: KPIs for Bsc IIT

Co-funded by the
Erasmus+ Programme
of the European Union
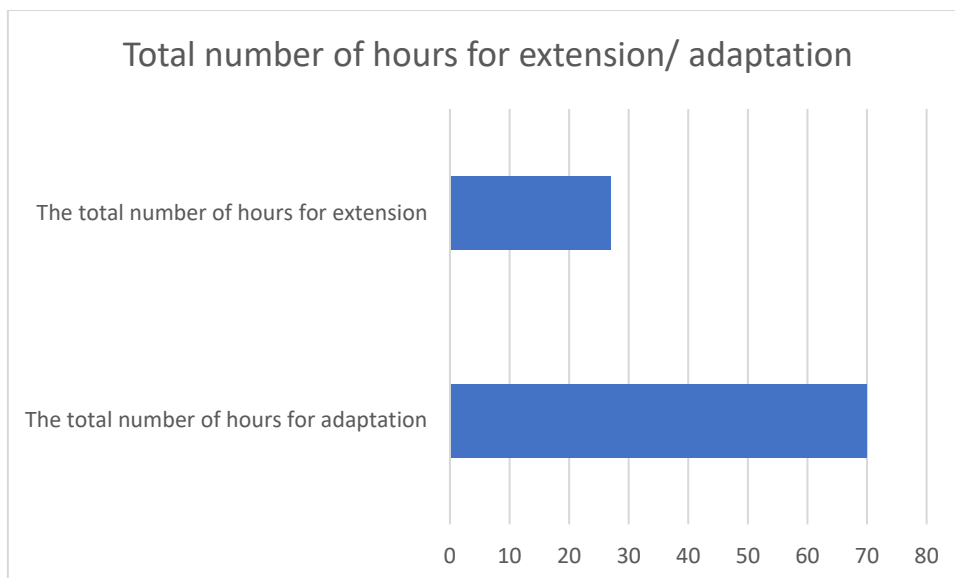
Enhance
Maintenance – Production – Quality

Figure 4: Total number of hours for extension/adaption

During the IIT-sfax TT session, 13 trainers participated to this training session, with 69,23% of women and 30,76% of men (see Figure 5). It is beyond the target (5 to 10 trainers).
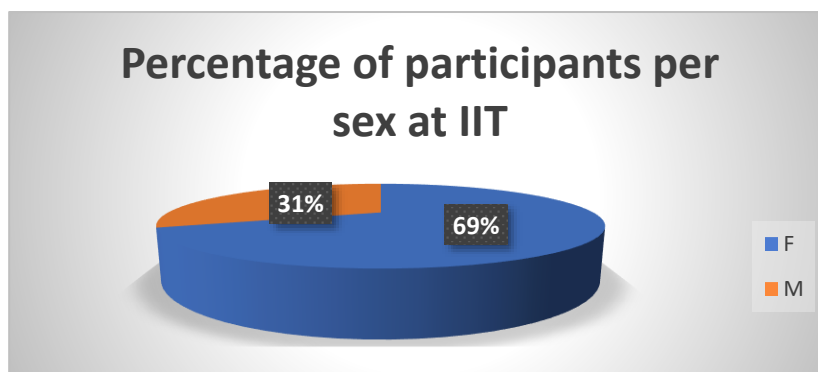

Figure 5: Percentage of participants TT session per sex at IIT

Table 11 shows the average scores (from 1 to 5) assigned by the trainee participants to each training activity and obtained from the evaluation forms.

Table 11: Average scores of the training activities at ITT training trainers' session

Name the activitiy	Avg of Q1	Avg of Q2	Avg of Q3	Avg of Q4	Avg of Q5	Avg of Q6	Avg of Q7	Avg of Q8	Avg of Q9	Avg of Q10	Moyenne
Act U3.1 Sensors sensitivity analysis and selection	3,80	4,40	4,40	4,80	4,00	4,25	4,50	4,75	4,75	5,00	4,47
Act U.2.5 Digital control systems (DCSs)	4,00	4,00	3,50	5,00	5,00	4,00	5,00	3,50	4,50	5,00	4,35
Act 5.2: Non-Conformities RCA and Quality gates design	3,80	4,20	4,00	4,00	3,25	3,00	4,40	4,00	4,20	3,80	3,87
Act 4.4: KPI, Dashboarding and data visualisation	4,50	5,00	4,50	5,00	4,00	3,00	3,50	5,00	4,50	4,50	4,35
Act 4.2: VSM for production 4.0	5,00	5,00	5,00	5,00	4,33	3,33	3,33	4,67	4,67	4,67	4,50
Act 3.1: Design and development of smart Production Planning/Scheduling systems	4,50	4,67	4,67	4,50	4,33	3,67	3,67	4,33	4,50	4,17	4,30
Act 3.2: Planning and scheduling techniques and approaches in industry 4.0	4,00	4,33	3,83	4,67	3,83	3,50	3,83	4,33	4,17	3,67	4,02
Act 2.5 Industry 4.0 Asset & Maintenance Management Systems	3,20	3,50	3,20	3,40	3,00	4,00	4,00	4,00	3,20	3,60	3,51
Act U.2.1 Emerging uses of smart technologies for production planning and scheduling	4,50	5,00	4,00	4,00	4,00	4,50	5,00	4,50	4,50	4,50	4,45
Act 5.3: QC model design	4,33	4,00	4,50	4,33	3,67	3,83	4,17	4,50	4,17	4,50	4,20
Act U.3.3 IoT and BPM for Integrated VSM	4,33	4,67	4,00	4,00	4,00	3,00	3,00	4,33	4,33	4,67	4,03
Act 3.5: Big data and predictive inventory analytics	3,60	3,60	3,40	3,60	3,60	3,80	3,40	4,00	4,00	4,00	3,70
Act 1.3 Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 context	3,60	3,40	3,60	3,60	3,40	2,80	3,20	3,60	3,60	3,40	3,42
Act 3.4: Data-driven planning/scheduling models and algorithms	3,20	3,80	3,40	3,60	3,20	3,80	4,00	3,60	3,00	3,00	3,46
Act U.2.3 CPS design and development	4,00	4,00	3,50	4,00	4,50	4,50	4,00	4,50	5,00	3,50	4,15
Total Avg	**3,95**	**4,16**	**3,97**	**4,18**	**3,74**	**3,63**	**3,89**	**4,20**	**4,10**	**4,03**	

By quickly analysing these data, we can see that:

- Most activities are well scored (general average of 4,052 for a scale from 1 to 5): the best score is 4,5 for "Act 4.2: VSM for production 4.0", and the lowest is 3,42 for "Act 1.3 Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 context".

- There is a certain dispersion between both TAs and Questions average scores.

5.2. UIT training trainers' session

The partner UIT has chosen two programs to be part of this project: MSc and BSc. The Figure 6 shows the KPIs used for the assessment of the IIT training trainer session.
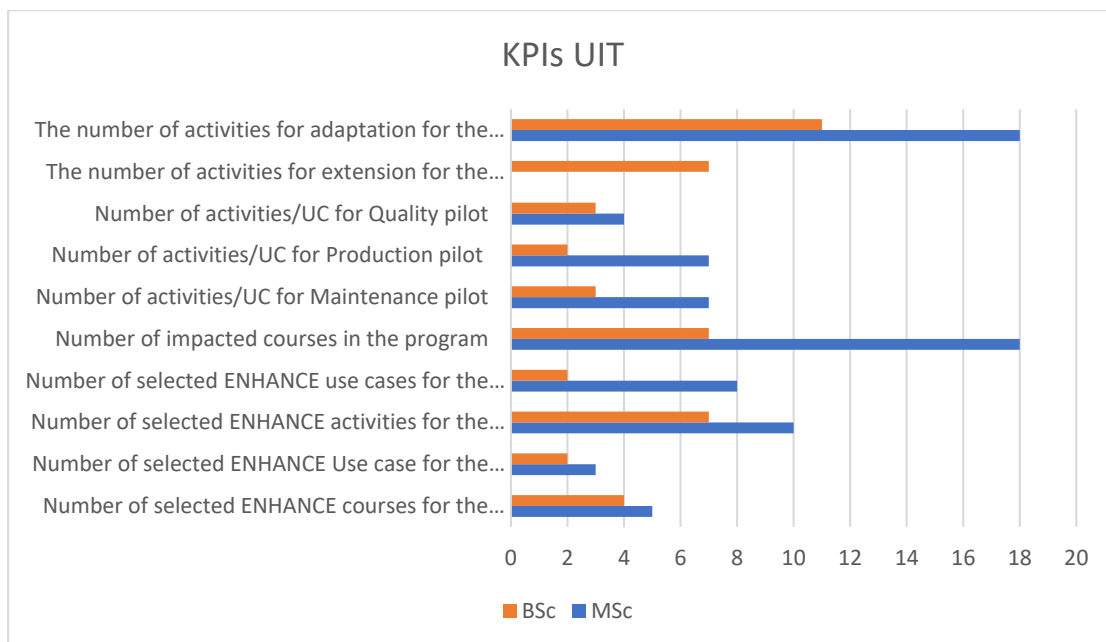

Figure 6: KPIs for UIT programs
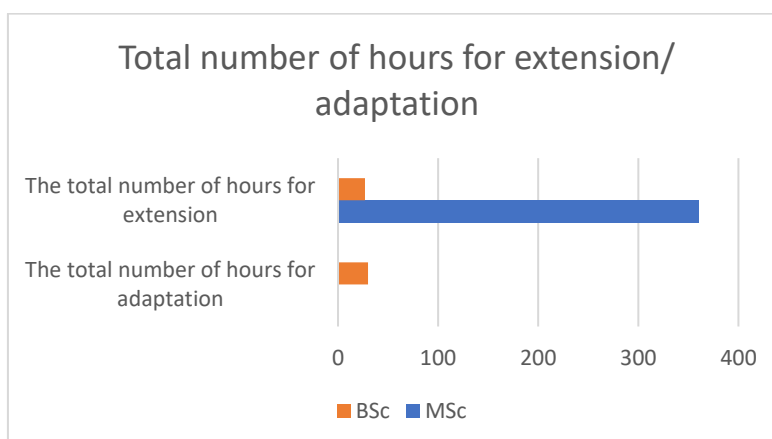

Figure 7: Total number of hours for extension/adaption

The Figure 6 and Figure 7 show that for the UIT, the MSc programme will consume more training activities than the BSc programme. In addition, the number of hours of extension of the MSc program is the highest. The exploitation Period for UIT is starting from 2022/2023 academic year.

Furthermore, 14 trainers participated to UIT training trainers' session, which is beyond the target (5 to 10 trainers). As it shown by Figure 8, the participants are divided almost equitably by sex: 58% of women and 42% of men.
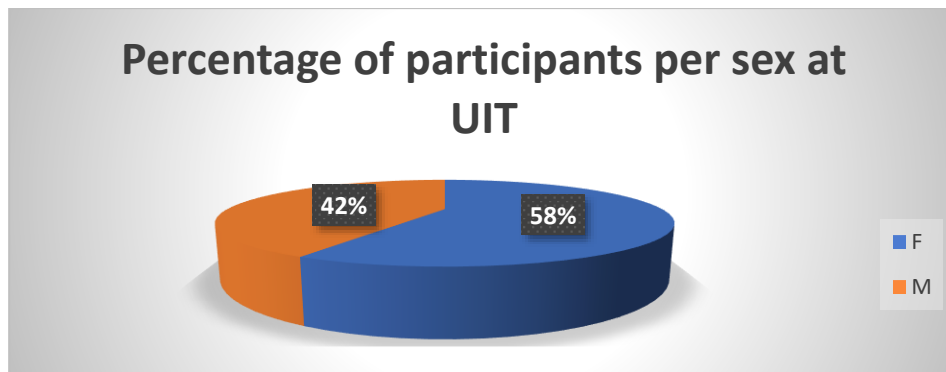

Figure 8: Percentage of participants per sex at UIT

Table 12 shows the average scores (from 1 to 5) given by the trainee participants to each training activity and obtained from the evaluation forms.

Table 12: Average scores of the training activities at UIT training trainers session

Name of the task	Avg of Q1	Avg of Q2	Avg of Q3	Avg of Q4	Avg of Q5	Avg of Q6	Avg of Q7	Avg of Q8	Avg of Q9	Avg of Q10	Avg
Act 1.4 Contributions of Smart Maintenance 4.0 to Energy Management & Energy Efficiency of Industry 4.0 Assets	4,40	4,60	4,00	4,40	3,80	4,00	4,25	4,25	4,75	4,75	4,32
Act 5.5: IoT and BPM for Integrated VSM	4,40	4,20	4,20	4,00	4,40	4,20	3,80	4,25	4,40	4,40	4,23
Act 4.2: VSM for production 4.0	4,60	4,40	4,00	4,40	3,60	3,60	3,40	4,20	4,00	4,20	4,04
Act 4.4: KPI, Dashboarding and data visualisation	4,67	4,67	4,67	4,67	4,67	3,67	3,67	4,67	4,67	4,67	4,47
Act 2.2: Maintenance planning and scheduling	4,00	4,00	4,00	4,40	4,00	3,00	3,00	3,67	3,33	4,00	3,74
Act U.1.3 ML and application for maintenance	4,25	4,75	4,50	4,75	4,25	4,25	4,67	4,50	4,50	4,00	4,44
Act U3.1 Sensors sensitivity analysis and selection	4,50	4,50	4,50	4,50	4,50	4,50	4,50	4,50	4,50	3,50	4,40
Act 4.1: PLM and Digital Factory	4,50	4,50	4,50	5,00	4,00	3,50	3,50	4,00	3,50	3,50	4,05
Act 5.2: Non-Conformities RCA and Quality gates design	4,40	4,60	4,20	5,00	4,00	3,20	3,40	4,60	4,20	4,80	4,24
Act 3.2: Planning and scheduling techniques and approaches in industry 4.0	4,25	4,25	3,75	4,00	3,50	4,25	4,25	4,50	4,50	4,50	4,18
Act 5.3: QC model design	5,00	4,67	5,00	4,67	4,67	4,33	4,33	5,00	5,00	4,33	4,70
Act 3.3: Methods and frameworks for control systems in agile manufacturing	4,25	4,50	3,75	4,00	4,25	4,25	4,25	4,50	4,25	4,00	4,20
Act U.2.3 CPS design and development	5,00	4,33	5,00	4,33	4,33	4,33	4,33	5,00	5,00	4,33	4,60
Act 1.2 Sensor Network Design in Smart Maintenance 4.0 contexts	4,75	4,50	4,75	4,75	4,00	3,75	3,75	4,50	4,25	4,25	4,33
Act 2.4 Downtime forecast and optimal maintenance planning	5,00	4,50	5,00	4,50	4,50	4,50	4,50	5,00	5,00	4,00	4,65
The usage of a zComponent from the ZDMP project (Data Acquisition or Message Bus or Monitoring and Alerting...).	4,00	4,00	4,50	4,50	4,00	4,50	4,00	4,50	3,50	3,50	4,10
Act U.2.1 Emerging uses of smart technologies for production planning and scheduling	4,50	4,50	5,00	4,50	5,00	4,50	4,00	5,00	4,50	3,50	4,50
Act U.3.5 Prescriptive and adaptive decision for Quality Control	4,75	4,25	4,75	4,25	4,00	4,25	4,25	4,75	4,75	4,50	4,45
Act 4.3: Virtual Reality for simulation	4,50	4,50	5,00	4,50	5,00	4,00	4,00	5,00	4,50	3,50	4,45
Total avg	**4,48**	**4,42**	**4,38**	**4,45**	**4,15**	**3,98**	**3,95**	**4,52**	**4,38**	**4,22**	**4,29**

By analysing these data, we can see that:

- Most activities are well scored (4.29 in average): the best score is 4,7 for "Act 5.3: QC model design", and the lowest is 3,74 for "Act 2.2 Maintenance Planning and Scheduling".

- There is a certain dispersion between both TAs and Questions average scores.

- The TA Act 5.3 with best score (4,7) has been used in the two TT sessions and his score has been improved (4,2 in the first TT session), while the trainees were not the same in the TT sessions. This can be considered as a proof of the improvement of this TA.

- The TA with a lowest score was used for the first time in the second TT.

5.3. UCAR training trainers' session

The partner UCAR has chosen four programs to be part of this project: MSc IIA, BSc IMI, MSc Quality and MSc BC. Figure 9 and Figure 10 show the KPIs used for the assessment of the UCAR training trainers' session.
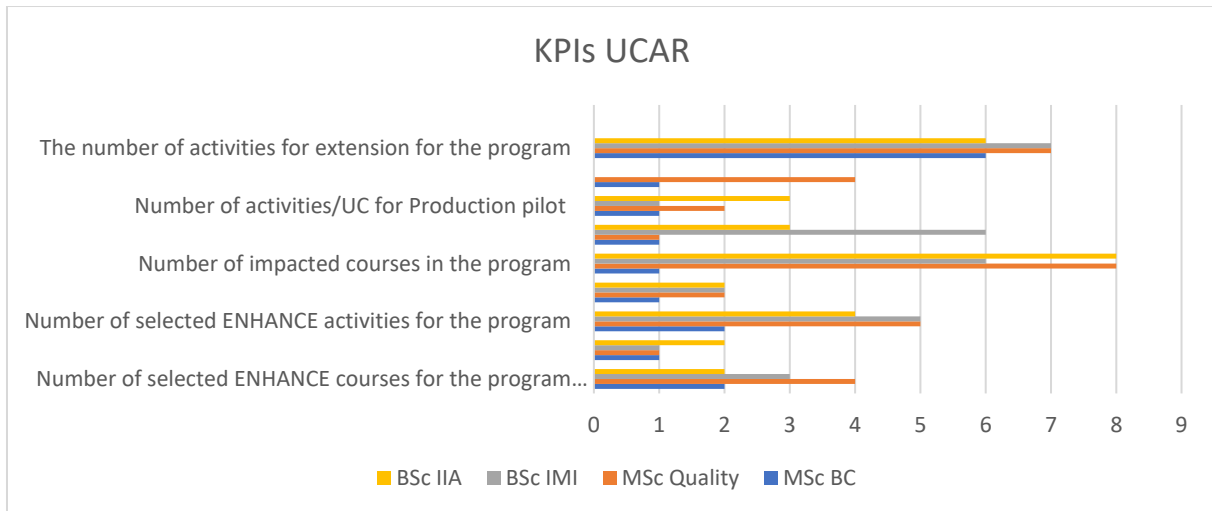
Co-funded by the
Erasmus+ Programme
of the European Union

Enhance
Maintenance – Production – Quality

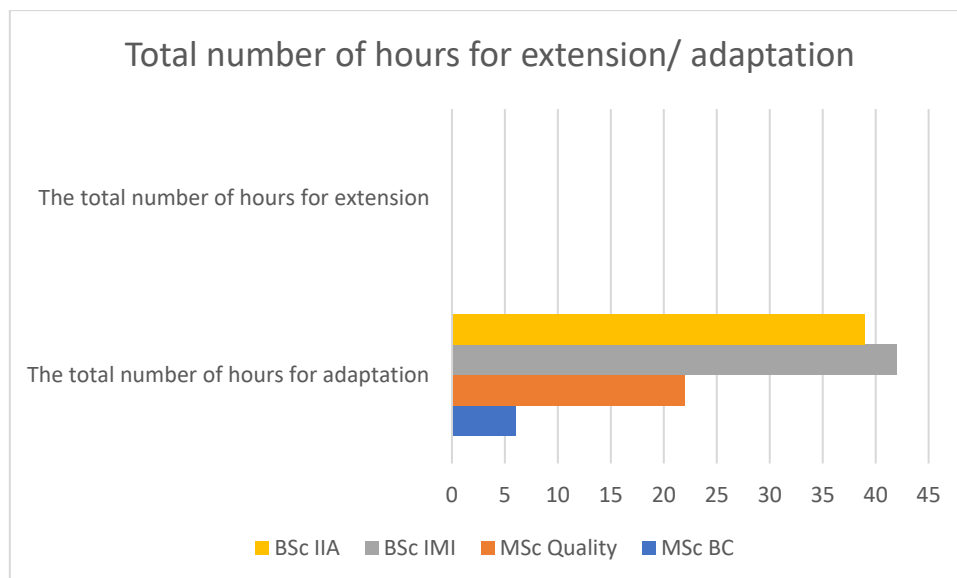*Figure 9:* KPIS for UCAR programs

Figure 10: Total number of hours for extension/adaption

According to Figure 10 for all UCAR programmes, there is no course that will be extended. In addition, only two programs choose the activities for quality pilot. The exploitation Period for UCAR is starting from 2023/2024 academic year.

During the UCAR training trainer session, 9 trainers participated to this UCAR training session, with 57,90% of women and 42,10% of men (see Figure 11). It is beyond the target (5 to 10 trainers).
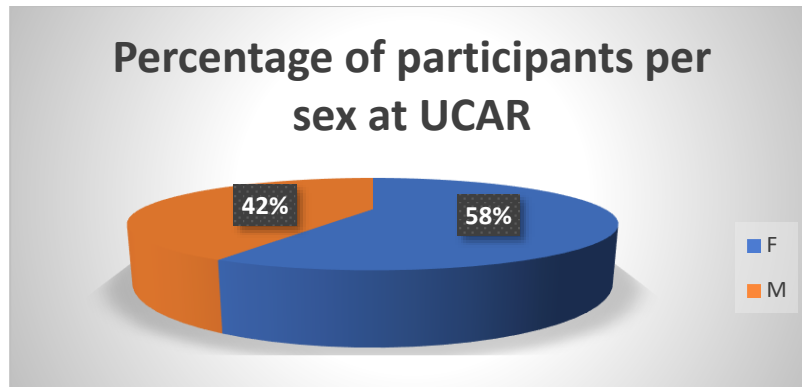
Co-funded by the
Erasmus+ Programme
of the European Union

Enhance
Maintenance – Production – Quality

Figure 11: Percentage of participants per sex at UCAR

Table 13 shows the average scores (from 1 to 5) assigned by the trainee participants to each training activity, and obtained from the evaluation forms.

Table 13: Average scores of the training activities at UCAR training trainers session

Name of the activity	Avg of Q1	Avg of Q2	Avg of Q3	Avg of Q4	Avg of Q5	Avg of Q6	Avg of Q7	Avg of Q8	Avg of Q9	Avg of Q10	Avg
Act 2.5 Industry 4.0 Asset & Maintenance Management Systems	4,33	4,17	4,33	4,00	3,50	3,33	3,33	4,17	3,67	4,40	3,92
Act U.1.3 ML and application for maintenance	4,60	4,60	4,40	4,40	4,60	2,50	3,50	4,75	5,00	4,75	4,31
Act U.2.5 Digital control systems (DCSs)	4,75	4,25	4,50	4,50	4,75	4,50	4,00	4,75	4,75	4,67	4,54
Act 1.2 Sensor Network Design in Smart Maintenance 4.0 contexts	4,60	5,00	4,40	4,80	4,80	4,60	4,40	4,60	4,80	4,80	4,68
Act U.1.2 Data acquisition and storage in industry 4.0	1,50	1,25	1,33	2,00	1,00	1,00	1,67	1,75	1,50	1,00	1,40
Act 2.2: Maintenance planning and scheduling	4,50	4,00	3,50	3,50	4,33	2,33	2,67	4,00	4,00	3,50	3,63
Act 3.2: Planning and scheduling techniques and approaches in industry 4.0	4,60	4,40	4,20	4,20	4,60	4,40	4,00	4,40	4,60	4,40	4,38
Act 3.5: Big data and predictive inventory analytics	4,00	3,75	3,25	4,33	4,50	3,50	3,67	4,00	3,67	4,33	3,90
Act 1.4 Contributions of Smart Maintenance 4.0 to Energy Management & Energy Efficiency of Industry 4.0 Assets	4,33	3,67	3,80	4,17	3,83	3,00	4,33	4,25	3,50	3,50	3,84
Act 5.2: Non-Conformities RCA and Quality gates design	4,00	3,67	4,50	4,67	4,00	3,50	3,00	5,00	5,00	5,00	4,23
Act U.3.2 Non-Conformities RCA and Quality gates design	5,00	4,33	4,67	5,00	4,67	4,33	3,67	4,33	4,67	4,50	4,52
Act 4.4: KPI, Dashboarding and data visualisation	4,60	3,80	3,60	4,20	3,60	3,20	2,80	4,40	4,40	4,20	3,88
Act 4.2: VSM for production 4.0	3,60	3,40	3,60	3,40	3,40	3,80	3,60	4,00	4,00	3,80	3,66
Act U.3.3 IoT and BPM for Integrated VSM	4,25	4,25	4,25	4,75	4,50	3,75	3,75	4,50	4,50	4,50	4,30
Act 6.3: Inspection Methods, sampling, Inspection Plan	4,50	4,50	4,50	4,50	4,50	3,50	3,50	4,50	4,50	4,50	4,30
Total Avg	**4,21**	**3,94**	**3,95**	**4,18**	**4,05**	**3,48**	**3,50**	**4,22**	**4,15**	**4,11**	

By analysing these data, we can see that:

- Most activities are well scored: the best score is 4,68 for "Act 1.2: Sensors network design", and the lowest is 1,4 for "Act U 1.2 Data Acquisition and storage in industry 4.0".

- There is a certain dispersion between both TAs and Questions average scores.

- The TA Act 5.3 with best score (4,68) has been used in the two TT sessions and his score has been improved (3,33 in the first TT session), while the trainees were not the same in the TT sessions. This can be considered as an indicator of the improvement of this TA.

- The TA with a lowest score was not sufficiently well done. The score is very low in respect to the average and necessitates certainly an improvement.

5.4. ECC training session for trainers

For ECC, one program has been chosen to be targeted by this project, it's about General Engineering ("Ingénieur géneral- Ing Gen"). The Figure 12 shows the KPIs used for the assessment of the ECC training trainers' session.
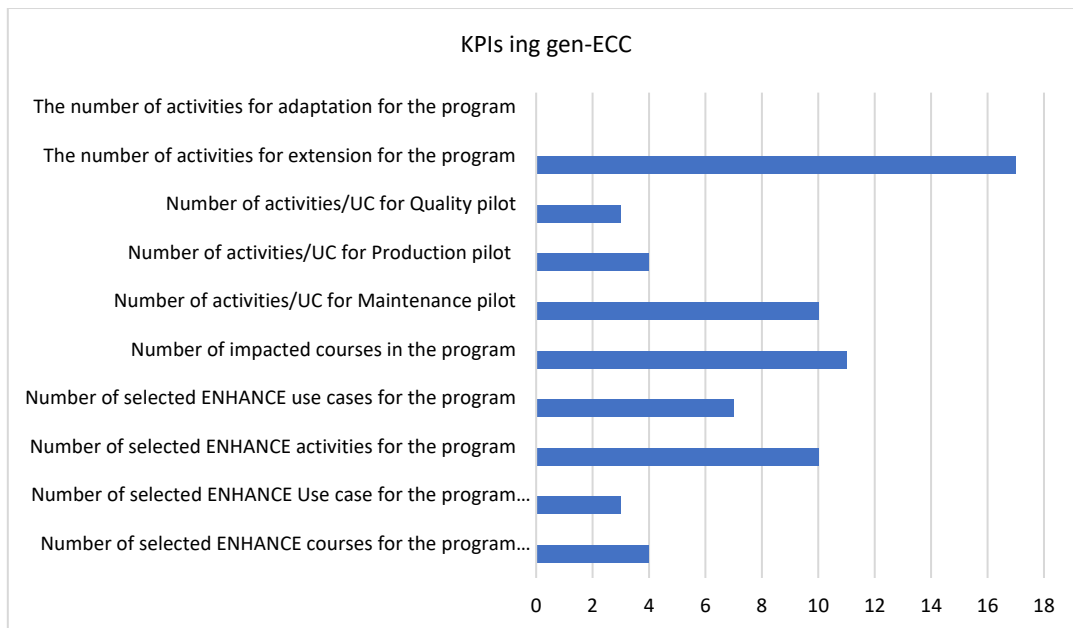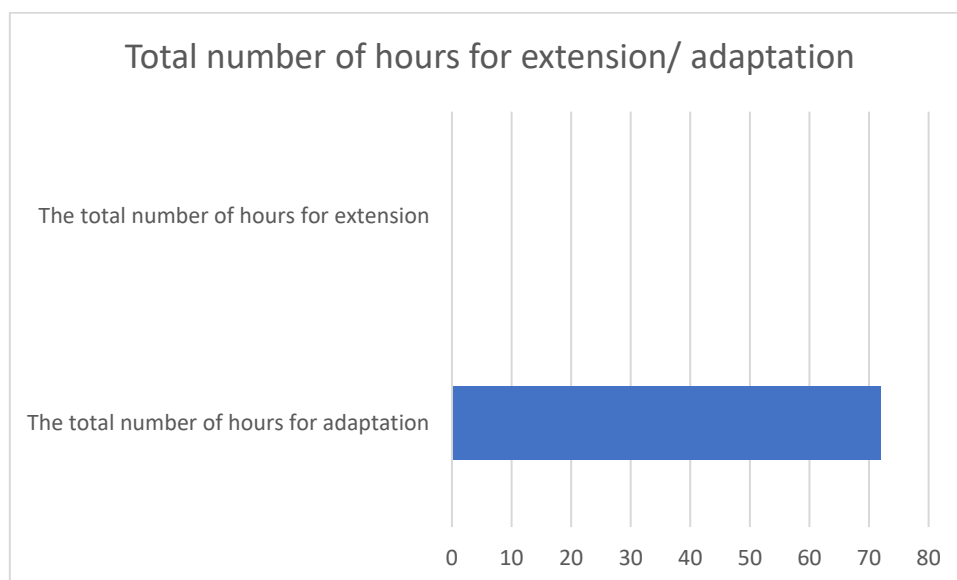
Figure 12: KPIs for ECC programs

Figure 13: Total number of hours for extension/adaption

According to Figure 13, there is no courses that will be extended for the ECC programmes

The exploitation Period for ECC is starting from 2023/2024 academic year.

During the ECC train-the-trainer session, 13 trainers participated to this ECC training session, with 61,54 % of women and 38,46% of men (see Figure 14). It's beyond the target (5 to 10 trainers).
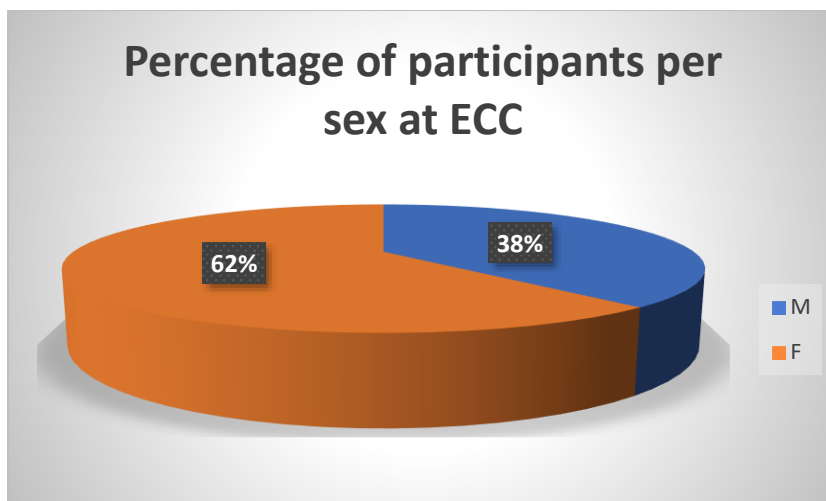
Figure 14: Percentage of participants per sex at ECC

Table 14 shows the average scores (from 1 to 5) assigned by the trainee participants to each training activity and obtained from the evaluation forms.

Table 14: Average scores of the training activities at ECC training trainers' session

Name of the activity	Avg of Q1	Avg of Q2	Avg of Q3	Avg of Q4	Avg of Q5	Avg of Q6	Avg of Q7	Avg of Q8	Avg of Q9	Avg of Q10	Avg
Act 3.1: Design and development of smart Production Planning/Scheduling systems	4,14	3,71	3,67	4,00	3,43	2,71	3,71	4,00	4,14	3,57	3,71
Act 1.1 Use cases of eXtended Reality (XR) in Smart Maintenance 4.0 contexts	3,40	3,80	3,60	3,40	3,60	2,75	3,25	3,60	3,60	3,00	3,40
Act U.1.3 ML and applications for maintenance	5,00	5,00	5,00	5,00	5,00	3,33	3,33	4,33	4,67	4,67	4,53
Act 1.5 Sustainability Driven Smart Maintenance 4.0	5,00	4,00	5,00	5,00	5,00	3,00	4,00	5,00	5,00	5,00	4,60
Act 2.2: Maintenance planning and scheduling	3,80	3,20	3,40	2,60	3,20	3,00	2,67	2,75	3,75	2,50	3,09
Act U.1.2 Data acquisition and storage in industry 4.0	4,50	3,00	3,50	3,00	3,00	4,00	3,00	4,00	3,00	3,50	3,45
Act 1.3 Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 context	4,60	4,20	4,40	4,00	3,60	3,40	3,40	4,00	4,20	4,00	3,98
Act U.2.1 Emerging uses of smart technologies for production planning and scheduling	4,67	4,00	4,33	3,33	4,00	3,00	3,67	3,67	4,67	3,33	3,87
Act 6.1: Integrated process improvement	3,67	2,33	3,00	3,00	2,33	3,67	2,67	3,00	3,00	2,33	2,90
Act 5.5: VSM for production 4.0	5,00	4,33	4,33	5,00	4,00	4,00	4,00	4,33	4,33	4,33	4,37
Act 1.2 Sensor Network Design in Smart Maintenance 4.0 contexts	4,00	4,00	4,33	4,00	4,00	3,33	3,33	3,67	4,00	3,33	3,80
Act U.1.1 Real-time communication	4,00	3,00	3,67	4,33	3,67	3,00	2,67	4,00	3,67	3,00	3,50
Act 2.4 Downtime forecast and optimal maintenance planning	4,00	4,00	4,00	3,00	4,00	1,50	1,50	4,50	4,50	2,00	3,30
Act U.1.4 KPI, Dashboarding and data visualisation	4,00	3,50	4,00	3,50	4,00	4,00	4,00	3,50	3,50	3,00	3,75
Act 3.5: Big data and predictive inventory analytics	4,00	4,50	4,00	4,50	4,50	3,00	3,50	3,50	4,50	2,50	3,85
Act U.2.4 Data-driven inventory management	4,00	4,00	3,00	4,00	3,00	2,00	4,00	3,00	3,00	3,00	3,30
Act 6.4: Prescriptive and adaptive decision for Quality Control	4,50	4,50	3,00	4,00	3,50	2,00	2,50	4,00	4,00	3,00	3,50
Act U.3.5 Prescriptive and adaptive decision for Quality Control2	4,50	4,50	3,00	4,00	3,50	2,00	2,50	4,00	4,00	3,00	3,50
Total Avg	**4,20**	**3,81**	**3,85**	**3,80**	**3,67**	**3,04**	**3,24**	**3,79**	**3,98**	**3,32**	**3,67**

By analysing these data, we can see that:

- The activities are not well scored as in previous TT sessions (3,67 in average): the best score is 4,60 for "Act 1.5: Sustainability Driven Smart Maintenance 4.0", and the lowest is 2,90 for "Integrated process improvement".

- There is a certain dispersion between both TAs and Questions average scores.

- TA Act 1.5 has got the best score (3,67), although it has been used one time in TT sessions. This does not exclude the need to improve it once presented to another audience 5 PDCA process).

- The TA with the lowest score in the previous TT session (1,9) has been improved since his score is now 3,45.

5.5. Impact on programmes Analysis

As the number of TT sessions was only four and the number of activities was high (40), it was not possible to plan and evaluate each TA at least two or three time in the TT sessions. In addition, the trainers invited in these TT sessions had different fields of interest in topics MPQ-4.0. Therefore, it is necessary to keep in mind according to the previous data analysis that a process PDCA (plan, Do, Check, Act) for a continuous improvement of TA by the trainers trained and the digital innovation HUB is highly recommended.

In this section, we set the focus on a global analysis of the results obtained after all TT sessions, in terms of impact on targeted programmes.
Figure 15 (resp. Figure 16) gives the selection frequency of each use-case's training activity (resp. course's training activity).
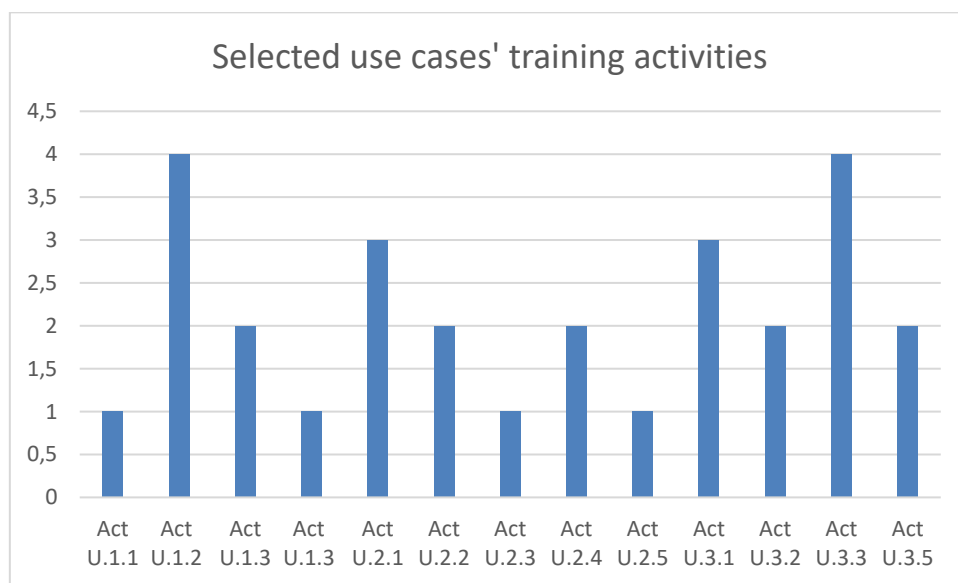

Figure 15: The Selection frequency each use-case's training activity
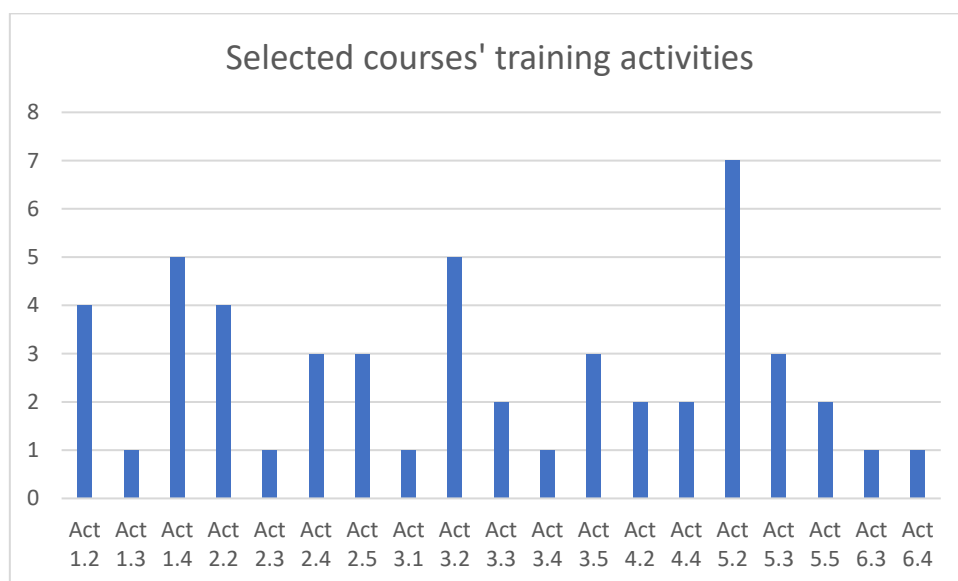

Figure 16: The selection frequency of each course's training activity

First of all, one can summarize the main results of these TT sessions by the following **General KPI:**
- Total hours of adaptation of existing targeted programmes: 207 hours
- Total hours of extension of existing programmes: 389 hours
- The number of selected activities (at least by one partners): 32 on 40 developed activities
- The number of participants is beyond the target (5 to 10 trainers per partner) for all partners.

From Figure 15 and Figure 16 , one can deduce that:
The most selected CTA/UTA per programme are:
- Act 5.2: Non-Conformities RCA and Quality gates design, selected by 7 partners,
- Act U.1.2: Data acquisition and storage in industry 4.0, selected by 4 partners.
- Act U.3.3: IoT and BPM for Integrated VSM, selected by 4 partners.

The least selected CTA/UTA per partner are:
- Act 1.3: Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 contexts
- Act 2.3: Contributions of Industry 4.0 technologies to Total Productive Maintenance
- Act 3.1: Design and development of smart Production Planning/Scheduling systems
- Act 3.4: Data-driven planning/scheduling models and algorithms
- Act 6.3: Inspection Methods, sampling, Inspection Plan
- Act 6.4: Prescriptive and adaptive decision for Quality Control
- Act U 1.1: Real time communication
- Act U 1.2: Data acquisition and storage in industry 4.0
- Act U 1.3: ML and application for maintenance
- Act U 2.3: CPS design and development
- Act U 2.5: Digital control systems (DCSs)

Each one of these CTA/UTA was selected by only one partner because the selection of CTA/UTA depends on the needs of each partner and each HEI programme. In addition, not all the CTA/UTA were developed at the same time; therefore, for the first organized training sessions, some training activities were not at a level of maturity that could be used.
It is also important to notice that the adoption/exploitation of training activities mainly depends on, among other criteria, the existing courses and the level of freedom that trainers must update them or to create new ones.
On the other hand, by analysing the selection frequency by programmes of each training activity, given by Figure 167, shows that:

Most two selected CTA /UTA per programmes:
- Act 2.2: Maintenance planning and scheduling: selected by all partners,
- Act U.1.3: ML and application for maintenance: selected by all partners.

Four CTA and two UTA are not selected by any partner. These CTA/UTA are:
- Act 2.1: Data-Driven Reliability for Smart Maintenance 4.0
- Act 5.1: Integrated thinking system modelling and development
- Act 6.2: Quality Process maturity self-assessment and life cycle management
- Act 6.5: Quality Planning, Control and Management functions
- Act U.2.2: Horizontal and vertical integration & Workflow management
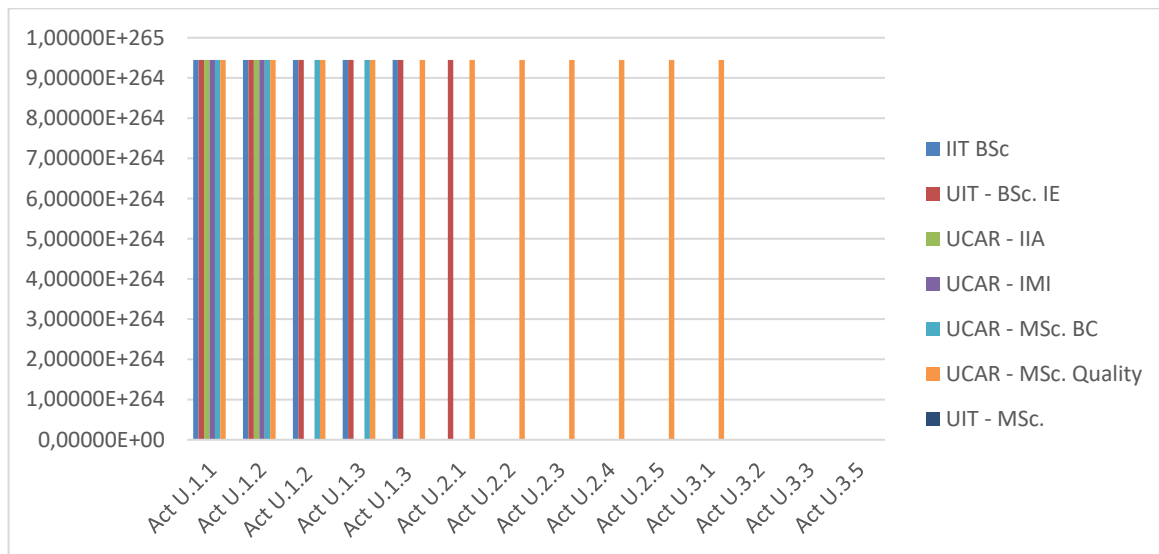- Act U.3.4: Process maturity self-assessment and life cycle management

Figure 17: Activities selection per programme

6. Training industrial staff sessions

In addition to the round of conducted training trainers' sessions, the developed training activities are used to train groups of industrial staff in Morocco and Tunisia. At these training sessions, some groups of students have participated and trained. This section gives some data about these training industrial staff and students sessions.

6.1. ECC training industrial staff session

The partner ECC Casablanca organized the first training industrial staff and students' session, for which 5 training activities was selected and used.

The number of participants at this ECC training session was 42 Industrial representative, for the 7 different training activity sessions, with an average of 6 participants per session. The industrial participants are from 8 following companies:

- Green energy park (GEP)
- ONCF
- Le wagon
- Missippi state university
- Bank almaghrib
- FORAFRIC
- Les domaines agricoles
- OCPA

6.2. UIT training industrial Staff session

The second training industrial staff and student session was organized by the partner UIT, for which 8 training activities was selected and used.

The number of participants at this UIT training session was 77 Industrial representative and 27 students for the 12 training activity sessions with an average of 8,6 participants per session. The industrial participants were from 20 companies:

Super Ceram	Snop	Adient
HM Fitting	OCP sa	Xperlean
Trelleborg	You and me consulting	Plastic omnium lighting
Tesca	Flores confec	Oxycoupe
Tuyauto	Simoldes plasticos	ONEE-be
Coficab	FMIA	HTL
Centrale danone	Ramaqs	

6.3. IIT training industrial staff session

The third training industrial staff and students' session was organized by the partner IIT, for which 10 training activities was selected and used.

The number of participants at this IIT training session was 9 industrial representative and 40 students for the different 10 training activity sessions with an average of 4,9 participants per session. The industrial participants were from 4 companies:

MPBS	Medlight
GCT	Technopaper

6.4. UCAR training industrial staff session

The fourth training industrial staff and student session was organized by the partner UCAR, for which 9 training activities was selected and used. The number of participants at this UCAR training session was 28 Industrial representatives for the different 10 training activity sessions. The industrial participants were from 19 companies:

CapBonInnov	UACPA Boujbel	Citruslab Biotech
CNRSM	OMICCT	Plastik-Sfax
Provesta	Lean manufacturing company	ENAF
APII	Xirit.tn	MG Motors
Elite	CDS	Super Metal
Cargoween	EMP	AMECAP
SASLAB		

6.5. Results analysis

Table 15 summarizes the main collected data from training industrial staff/students' sessions round.

Table 15: Training Industrial staff/students sessions data summary

Partner Country	Morocco		Tunisia		
HEI	ECC	UIT	IIT	UCAR	Total
Nb of					
Industrial representatives	42	77	9	28	156
Students	-	27	40	26	93
Enterprises	8	20	4	19	51
Used Training activities	7	8	10	9	34

As we can see in Table 15, the round of training industrial staff was a great success since it allowed to interest 51 enterprises, and to train 156 Industrial staff in the three field of MPQ-4.0, from the two partner countries: Morocco and Tunisia. This confirm what was established by the gap analysis done at start of the project and shows that there is a need of training in MPQ-4.0, expressed at least by some Moroccan and Tunisian enterprises in the regions of partner countries HEIs involved in this project. This need certainly will be the same in other regions. This fact should encourage a large dissemination of project outcomes and boost the collaboration between enterprises and universities via competences centres or Digital Innovation Hub.

On the other hand, the number of students invited in the training industrial sessions was voluntary limited, but it is important to emphasize here that the impact of the project on students is mainly guarantee through developed training activities adopted by HEI to update/extend their existing courses or to create new ones. Table 16 gives the number of students who are trained using some of the developed training activities. These training activities already adopted by some of the the partner countries' HEIs for the two academic years 2022/2023 and 2023/2024. These students are trained by the Trainers who are trained in training trainer sessions and by some members of consortium from Partner countries. As we can see in Table 16 the total of students is 704 and almost the double of the initial objective of 300.

Table 16: Number of students trained by TA of Enhance project, for the two academic years 2022/2023 and 2023/2024

The trainers Training sessions date & Location	Nb of Trained Students per partner and per programme for 2022-2023 Academic Year	Nb of Trained Students per partner and per programme for 2023-2024 Academic Year
Session 1 (IIT) : May 2022	Programme Indust Eng Bac+4 : 62 / Bac+5 : 60 **Total : 122**	Programme Indust Eng Bac+4: 62 / Bac+4 : 62 **Total : 124**
Session 2 (UIT): July 2022	Programme Indust Eng Bac+4 : 54 / Bac+5 41 Programme Ms IITN Bac+4: 27 / Bac+5: 27 **Total : 149**	Programmes Indust Eng Bac+4 : 56 / Bac+5 41 Programme Master Bac+4: 35 / Bac+5 : 27 **Total : 159**
Session 3 (UCAR): December 2022		Programme Ms BC Bac+4 : 15 Programme Msc Qu Bac+4 : 15 Programme Bsc IMI Bac+5 30/ Bac+4 : 30 Programme Bsc IIA Bac+5 : 30 / Bac+4 : 30 **Total: 150**

7. Training administrative staff sessions

In addition to the conducted rounds of training trainers/industrial staff/ students' sessions, which aims to evaluate and improve the developed content for selected training activities, two training administrative sessions were organized by partner countries (Morocco and Tunisia). These training sessions aimed to inform the administrative staff about the different types of ERASMUS Projects.
The emphasis was placed on recent developments concerning the management rules of the Erasmus+ project and on the life cycle of an Erasmus+ type CBHE project (preparation, mounting, submission, execution, closure, sustainability) to be able to support effectively by administrative staff.

7.1. IIT/UCAR training administrative staff session

This session was organised in collaboration with "Le bureau Erasmus+ Tunisie" (Local coordination Ersamus+ office), the November 30th, 2023. Figure 18 represent the flyer for training administrative announce.

Figure 18: Flyer for Training administrative staff

Figure 19 shows the agenda of this training session.

Heure	Titre de l'intervention
9h – 9h30	Présentation du programme ERASMUS+, *Nesrine Baklouti, NEO Tunisie*
9h30 – 10h	Règles de gestion des projets ERASMUS+, CBHE, *Nejib Moalla, Université Lumière Lyon 2, France*
10h – 10h15	Pause-café
10h – 12h	Atelier sur le montage des projets ERASMUS+, *Nesrine Baklouti, NEO Tunisie*

Figure 19: Agenda of Training administrative staff

The number of participants who attend this training session is:
- UCAR: 10 HEI administrative staff and 9 trainers.
- IIT: 8 HEI administrative staff and 5 trainers.
- ITBS: 1 administrative staff and 2 trainers.
- Polytech INT: 2 trainers.

The number of administrative who attend this workshop is 9.

7.2. UIT/ECC training administrative staff session

This session was organised in by the Partner UIT and animated by the CBHE ENHANCE project Manager on December the 15th, 2023. Figure 20 shows the Title and Objectives of this training session.

Figure 20: Objectives of the UIT/ECC Training administrative staff

During the administrative training session the official document "Erasmus+ CBHE, CBHE General InfoDay*" shown by Figure 21, were also used.

Figure 21: Document used during the UIT/ECC Training administrative staff
(*)https://www.eacea.ec.europa.eu/system/files/2023-12/CBHE%20Infoday%202024%20Call.pdf

The number of participants who attend this training session were 34, mainly from UIT.

8. Conclusions:

By conducting four training trainers' sessions at countries partners between May 2022 and Mars 2023, a total of 49 trainers were trained using 34 of developed training Activities. This led in training about of 704 students on the two academic years (2022-2023/2023-2024). These training sessions allowed having feedback on Training material content, and then its improvement to be more suitable for a large adoption by the targeted programmes.

By conducting four training industrial staff, about of 159 industrial representatives of 51 companies from Morocco and Tunisia, were trained using some of training activities where these Industrial staff were interested. The KPIs show in some extent that the conducted rounds of training sessions were successful. By uploading the developed, the 6 courses and the 3 use cases on the LeL platform, another lifelong rounds of training session begins...

Co-funded by the
Erasmus+ Programme
of the European Union

Enhance
Maintenance – Production – Quality

9. Appendix 1

Activity Evaluation Form

Name of the activity   :_____

Date of the training   :_____

Partner name   :_____

Directions: *On a scale of 1-5 (5 being the highest, best or most and 1 being the least, lowest or worst) rate by circling the number reflecting your opinion.*

To what extent the scope of the activity was clear?

Comment:_____   1 2 3 4 5

To what extent did the activity can contribute to improve existing courses in your institution?

Comment:_____   1 2 3 4 5

To what extent were the objectives stated at the beginning of the activity satisfied?

Comment:_____   1 2 3 4 5

To what extent did the activity contain significant current intellectual or practical content related to MQP4.0/Industry 4.0?

Comment:_____   1 2 3 4 5

What are the courses that may be impacted by this activity?

Name of courses	:_____
	:_____
	:_____

Exploitation: *On a scale of 1-5 (5 being the highest, best or most and 1 being the least, lowest or worst) rate by circling the number reflecting your opinion.*

To what extent the activity content is ready to be reused?

Comment:_____   1 2 3 4 5

To what extent additional adaptation efforts are needed to reuse the proposed activity contents?   1 2 3 4 5

Comment:_____

To what extent do you need support to adapt or adopt the proposed contents?

Comment:_____   1 2 3 4 5

Sustainability: On a scale of 1-5 (5 being the highest, best or most and 1 being the least, lowest or worst) rate by circling the number reflecting your opinion.

To what extent you consider the activity content is useful for other trainers training for the next three years?   1 2 3 4 5

Comment:_____

To what extent you consider the activity content is useful for students training for the next three years?   1 2 3 4 5

Comment:_____

To what extent you consider the activity content is useful for industrial workers training for the next three years?   1 2 3 4 5

Comment:_____

Any comments and recommendation to trainers
_____
_____
_____
_____
_____
_____
_____