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

## D1.5. Report on the training of HE staff

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Authors	Youssef ROCHDI
Contributors	All partners
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## **Executive Summary**

This document is the deliverable D1.5 in work package WP1 of Capacity Building in High Education ENHANCE project. It is a report on training High Education staff (trainers). Firstly, it gives the flowchart and rules used to select the MPQ4.0 Training activities according the outcomes of gap done in task 1.2. These activities will be developed later, in the work package WP2, and implemented later in the developed Learning framework. After it shows how the selected training activities organized as 6 common courses and 3 uses cases, and decomposed in tasks, can be used by trained trainers to update existent courses in Moroccan and Tunisian High education institutes. Then it establishes the planning of High Education staff training sessions based on selected MPQ4.0 training activities. Finally, it defines an evaluation process of developed training activities for refinement or improvement of developed training material.

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## 1. Introduction

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 workshop 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.

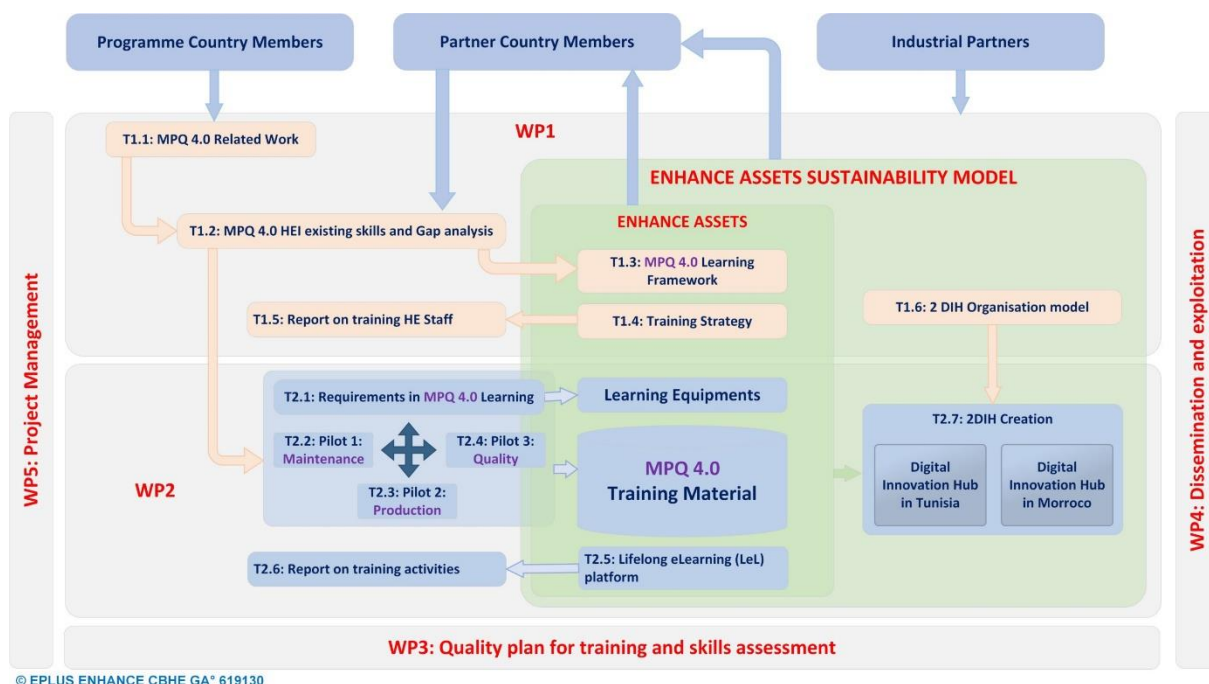


Figure 1. ENHANCE project organization.

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:

- 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 industrial staff training.



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.

### 1.1. Purpose of document

This deliverable is a report on the training strategy of PC's HEIs staff, which has been adopted to contribute to achieving the main objective of the ENHANCE project, i.e., building capacities in the MPQ4.0 field in HEIs.

It recalls in a synthetic way the work done in tasks T1.1, T1.2 and T1.4 which made it possible to select some MPQ4.0 training activities (T1.2 & T1.4). Let's emphasise here that these training activities should reduce the gap between skills targeted by M&T-HEIs programs and those needed in the MPQ4.0 field. This gap was evaluated in task T1.2, by analysing M&T-HEIs programs' contents and the state of the art established in T1.1.

First, the deliverable gives the main training activities' selection rules that have been adopted and their justification, as well as the constraints that have influenced this selection. Then, it shows how a reduced list of existing priority courses was established. These courses are either existing courses in M&T-HEIs' programs to be updated or new courses to be created by integrating the selected training activities.

Later, the deliverable shows how the adopted training strategy will be practically implemented, through:

- 1- The definition of the six courses and the three case studies to be developed and implemented in the training platform in the WP2 work package.
- 2- The appointment of trainers and the planning of training sessions for the benefit of trainers.
- 3- The definition of an evaluation process of developed training activities for refinement or improvement of developed training material.

### 1.2. Reference documents

- D1.2: MPQ4.0 HEI's existing skills and gap analysis.
- D1.3: MPQ4.0 Learning Framework.
- D1.4: Training strategy.

### 1.3. Applicability

This document's content will be used later as a guide for developing activities, in WP2 (T2.1, T2.2, T2.3, T2.4) and executing training sessions.

### 1.4. Definitions

**Training activity:** a set of training tasks that target some specific skills.

**Training activity material:** any type of content used to train, e.g., materials, presentations, documents, manuals, specifications, and videos...

**Course:** a set of coherent training activities, which target a set of skills in a specific field.

**Programme:** a set of coherent and complementary courses, which target the graduation of learners.

**Learning framework:** a web application that hosts a set of content and allows to manage training sessions that involve learners and trainers.

### 1.5. Structure of the document

This document is organized into 7 sections. After this introduction section **2** is an overview of the approach adopted to propose MPQ4.0 Training activities to be developed in the WP2 work package

and implemented in the developed Learning framework. Sections **3**, **4** and **5** give more details on this approach's steps. Section 6 shows how these training activities will be orchestrated in the learning framework while section 7 establishes the planning of High Education staff training sessions.

## 1.6. List of acronyms

- **CBHE** – Capacity Building in High Education
- **ENHANCE** – strENgthening skills and training expertise for TunisiAN and MoroCcan transition to industry 4.0 Era, Erasmus+ project.
- **WP1**: work package 1 of ENHANCE project.
- **WP2**: work package 2 of ENHANCE project.
- **T1.1** , **T1.2**, **T1.3**, **T1.4**: Task 1, Task2, Task 3 and Task 4 in the work package 1 WP1
- **HE** – High Education
- **HEI** – High Education Institute
- **MPQ4.0**– Maintenance, Production, Quality in the industry 4.0 context
- **MPQ4.0-LF** – MPQ4.0 Learning Framework
- **PC** – Partner Country
- **M&T-HEIs**– Moroccan and Tunisian High Education Institutes involved in ENHANCE Project
- **SMEs**: Small and Medium Enterprises
- **M&T-SMEs**: Moroccan and Tunisian Small, Medium Enterprises investigated.
- **LP**: Long-life Learning platform
- **MPQ4.0-TA**: Maintenance Production Quality 4.0 Training Activity(ies)

## 2. MPQ4.0 Training strategy's overview

As a CBHE project, ENHANCE aims to transfer knowledge and know-how related to topics of maintenance, quality, and production in the era of industry4.0 (what we will call MPQ4.0). The transfer targets academic or working learners, and HE staff by local trainers in the Moroccan and Tunisian Partner's HEI, based on the European partner's expertise in the industry4.0.

To achieve this objective MPQ4.0 training strategy has been adopted in this project. This strategy is summarized in the following main steps and illustrated in Figure 1. More details and information are given in the following sections.

### Step 1:

In task T1.1, a state-of-the-art of three MPQ4.0 topics has been established through an exhaustive literature review. This allowed highlighting the requested skills and involved digital technologies to master to be prepared for the digital transformation in maintenance, production and quality fields. Based on the outcomes of task T1.1, task T1.2 has had aimed to:

- analyse the gap between the requested MPQ4.0 skills/involved digital technologies and those targeted by M&T-HEIs' existing programs, in three topics of maintenance, quality and production.
- assess the maturity/readiness of Moroccan and Tunisian SMEs for the transition to MPQ4.0, and determine their real needs in this sense.

Task 1.2 resulted then in an extended list of skills to develop, to minimize the determined gap, through a proposal for an extended list of training activities related to MPQ4.0 topics (see D1.2).

### Step 2:

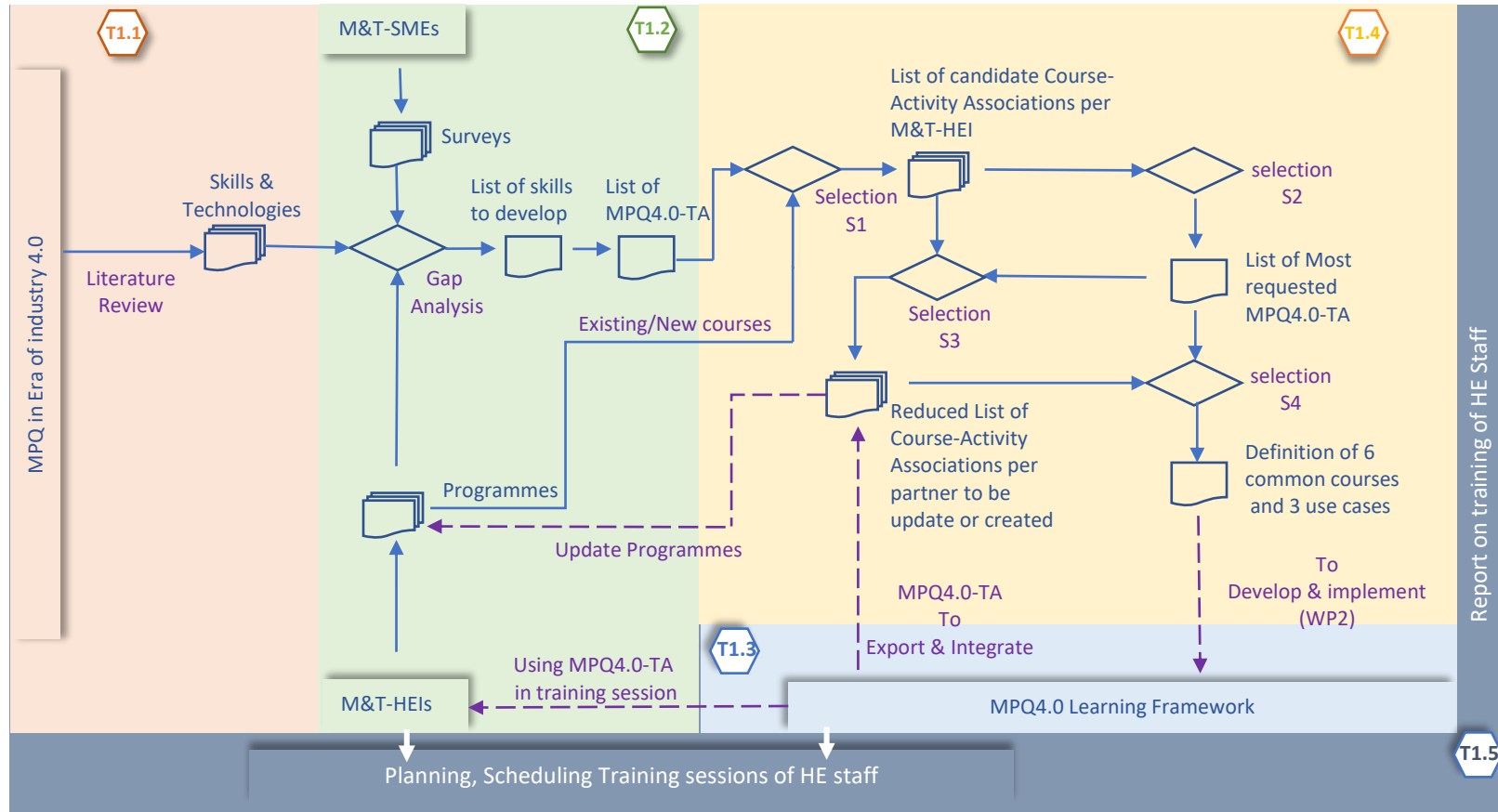
Each M&T-HEI has been selected, through a selection process "S1":

- a list of candidate courses to be updated among the existing ones in its involved programs,
- an eventual list of new courses to be created and integrated into the involved programs.

As shown in Figure 2, both of these types of courses, cited above, should integrate some selected MPQ4.0 training activities which target some skills highlighted by T1.2.

This first selection process gave a macroscopic idea of what can be done to update the existing programs so that they can meet the requirements of MPQ4.0 in terms of skills to develop and digital technologies to be familiar with.

The outcome of this selection process S1 is an extended list of candidate courses to update/create associated with some selected MPQ4.0 training activities.



MPQ4.0-TA Maintenance Quality Production 4.0 Training Activities  
M&T-SMEs Moroccan and Tunisian Small and Medium Enterprises  
M&T-HEIs Moroccan and Tunisian High Education Institutes

Figure 2– MPQ4.0 Training strategy

### Step 3:

Based on some rules that will be synthesized later in section 13, a reduced list of most requested MPQ4.0 training activities has been established. This is illustrated in Figure 2 by a selection process S2. As consequence, only the activities in this reduced list have been considered by:

- each Moroccan or Tunisian HEI, to reduce its initial list of candidate courses to be updated or created. It then obtained a reduced list of priority courses (which will integrate some activities among those in the reduced list of activities) to focus on; this selection is illustrated in Figure 2 by “selection process S3”.
- all partners to define six common courses (two by one topic of MPQ4.0), and three use cases. Each common course is related to a process in one of the three MPQ4.0 topics. It contains at most five activities (among those on the reduced list of activities). As the same, each use case is related to one of the three MPQ4.0 topics and will contain five activities (among those of the reduced list of activities); this selection process is illustrated by “selection process S4” in Figure 2. These defined common courses and use cases will be developed later in the work package WP2. These courses and use cases will be used to train the trainers in each M&T-HEI; this will be described in section 6.

### Step 4:

In parallel with the above three sequential steps, task T1.3 was dedicated to designing a learning framework MPQ4.0-LF, which will:

- host, in the beginning, all MPQ4.0 training activities material related to the six common courses and three use cases, that will be developed in the work package WP2.
- allow learners' skills/competencies assessment
- automatically generate, and manage training sessions using the learner's profile and training objectives.
- manage learner's access to training material
- host further MPQ4.0 training activities material, which will be developed autonomously by each HEI in the future. This sustainable development beyond the end of the project is also one of the ultimate objectives of this capacity-building project.

In conclusion, the approach adopted in this project began with the determination of a gap between what M&T-HEIs have now and what they should have, as training programs concerning MPQ4.0 topics. Then it defined a set of training activities which will be developed to reduce, in the short term, this identified gap. But also it allows achieving sustainability through a "how-to" process, by incremental improvement and smoothy adaptation of the existing training programs to the requirements of MPQ4.0.

## 3. Synthesis of MPQ4.0 training activities selection rules

First of all, each M&T-HEI had to establish through a “selection process S1” (Figure 2) an initial list of candidate existing courses to be updated or eventually new courses to be created, by integrating the activities from a preliminary extended list of MPQ4.0 training activities. This list was established in task T1.2 (see D1.2) in response to identified gaps. However, the eight training programs of M&T-HEI involved in the ENHANCE project are more or less heterogeneous in their objectives and contents. So, the skills targeted by each program are more or less different. This finding was confirmed by the high number of identified skills to be developed. These skills were highlighted by the gap analysis. So, the

list of the preliminary MPQ 4.0 training activities proposed in task T1.2 is too extensive. It is obvious that it is impossible, to develop training material for all proposed activities in this extended list, due to the following main constraints:

- the limitation of available resources, i.e., the remainder time in the project (two years), available equipment in HEIs, budget to acquire new equipment, and effort to be supplied by HEI staff involved in this project.
- the impossibility to make a lot of changes in existing courses or the programs without the official approval of the Education Ministry and or the university. These changes necessitate a process of new curriculum accreditation query.

On the other side, it will be difficult to train simultaneously a lot of HEI staff in a short time. It is also more reasonable to make smooth and progressive changes in the M&T-HEIs programs, and more sustainable to show how each HEI can continue, itself, the transition to MPQ4.0 by an incremental approach.

Taking into consideration all of the previous arguments, it was necessary to reduce the preliminary extended MPQ4.0 training activities list using some selection rules. These rules are elaborated on and discussed by all the partners; they are summarized in the following:

- the training activities to retain, are those which are the most selected by M&T-HEIs, to maximise the impact of the most HEIs' programmes.
- the chosen activities for each one of the MPQ4.0 topics must be balanced in number and development effort.
- Some activities may require equipment. So, the possibility of implementing such activities by taking into account the budget allocated by the project for the purchase of equipment must be verified. This can be done in consultation with the European partners and taking advantage of their expertise in MPQ4.0 fields, as well as with equipment suppliers.

Based on these rules, the iterative selection process (selection S2 in Figure 2) was executed and was led to a reduced MPQ4.0 training activities list which is given in [Table 1](#).

*Table 1 Most requested MPQ4.0 Training activities*

Most requested Training activities for Maintenance topic	
Code	Training Activity
M1	Use cases of eXtended Reality (XR) in Smart Maintenance 4.0 contexts
M2	MPrev7 Sustainability Driven Smart Maintenance 4.0
M3	MPrev11 Facilities and Utilities: Energy Efficiency
M4	MPred1 Identify critical assets
M5	MPred3 Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 contexts
M6	Act 1.2 Sensor Network Design in Smart Maintenance 4.0 contexts
M7	MPred10 Data acquisition and storage in industry 4.0
M8	MPred7 Real-time communication
M9	MPred4 Implement CBM, PHM
M10	MPred5 ML and application for maintenance
M11	MC5 Organization and preparation of reassembly
M12	MPrev6 Data-Driven Reliability for Smart Maintenance 4.0
M13	MPrev8 CMMS dashboards and reporting functions
M14	MPrev9 Maintenance planning and scheduling in Industry 4.0 contexts
M15	MPrev10 Contributions of Industry 4.0 technologies to Total Productive Maintenance
M16	MPred9 Downtime forecast and optimal maintenance planning
Most requested Training activities for Production topic	
Code	Training activity
P1	PPS4 Emerging technologies for production planning and scheduling
P2	PPS6 Design and development of smart Production Planning/Scheduling systems
P3	PPS7 Planning and scheduling techniques in industry 4.0 and cloud manufacturing
P4	PPS11 Planning & Scheduling of robotic & cobotic systems
P5	PPS8 Data-driven planning/scheduling models and algorithms
P6	PIM2 Cloud-based inventory management
P7	PIM4 Big data and predictive inventory analytics
P8	PIM6 Inventory management dashboards
P9	PPMC12 Methods and frameworks for control systems in agile manufacturing
P10	PPS9 Cyber-Physical Production Systems design, assessment, evaluation models and security
P11	PPMC1 Real-time data acquisition
P12	PPMC4 IoT/CPS development and integration
P13	PPMC5 Interoperability, visibility, connectivity,
P14	PPMC7 PLM and Digital Factory
P15	PPMC9 Automated Value Stream Mapping
P16	PPMC11 Virtual Reality for simulation
P17	PPMC17 Emerging uses of industry 4.0 technologies for Occupational Health, Safety & Ergonomics
P18	PPMC13 Simulation and Digital Twins
P19	PIM9 Emerging smart technologies for Material Handling Systems
Most requested Training activities for Quality topic	
code	Training Activity
Q1	IoT and BPM for Integrated VSM
Q2	Non-Conformities RCA and Quality gates design
Q3	Sensors' sensitivity analysis and selection
Q4	QC model design
Q5	Design for X applied for Quality
Q6	Integrated thinking system modelling and development
Q7	Inspection Methods, sampling, Inspection Plan
Q8	Quality Info Records, Lot Inspection, Result Recording, Usage Decision
Q9	Prescriptive and adaptive decisions for Quality Control
Q10	Quality impact assessment and implementation
Q11	Integrated process improvement
Q12	Quality Process maturity self-assessment and lifecycle management

#### 4. Integration of selected MPQ4.0 activities to targeted courses:

Based on the list given in *Table 1*, each M&T-HEI has had to sort, in priority order, its initial list of courses to be updated or new courses to be created. This initial list was established by the “selection process S1” (Figure 2) and led to a list of association course/training-activity. By focusing on only activities among those in *Table 1*, the “selection process S3” (Figure 2) led to a final reduced list of priority courses per M&T-HEI. The reduced list contains priority existing courses to be updated, and eventually, priority new courses to be created by training activities in *Table 1*.

All the lists of priority courses per HEI are merged and classified by topics and given in *Table 2* to *Table 4*, where the MPQ training activities are designated by their codes given in *Table 1*. Indeed, *Table 2* to *Table 4* show the integration of MPQ training activities from *Table 1* in the priority courses selected by M&T-HEIs.

*Table 2. List of priority courses related to Maintenance topics to be updated /created*

Maintenance																		
HEI	Programme	Activity's Code																
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	
FSEGN	QI	Course					1									1		
		DMAIC methodology					1									1		
	Statistical Process Control															1	1	
BC	Intelligent methods and applications		1									1					1	
	INSAT	DataBases							1									
INSAT	IMI	Computer-Assisted-Maintenance Management		1								1			1	1		
		Data Transmissions						1	1	1								
		Industrial Information Systems: ERP & SAP							1									
		Production Logistics & Industrial Organization				1												
		Industrial Control & Supervision				1												
		IIA	Real-Time Computing								1							
	IIT	IE	Industrial networks & Sensor Networks						1									
			Logistics Chain & flow control				1											
			Industrial Performance Monitoring				1											
			Maintenance management / CMMS	1										1			1	
UIT	M.ERP	Reliability and Predictive maintenance of systems		1		1	1	1	1	1	1		1				1	
		Maintenance Planning and Reliability	1					1	1	1							1	
	ILE	Machine Learning et multi-agents systems										1						
		Industrial Maintenance & Reliability	1					1	1	1							1	
ECC		Machine Learning and multi-agents' systems										1						
		Maintenance Management	1	1	1	1	1				1	1	1	1				
		Reliability	1	1	1	1	1				1	1	1	1				
Statistics			5	5	6	3	3	5	6	5	3	7	3	3	1	3	3	



Table 3 List of priority courses related to Production topic to be updated /created

Production																					
HEI	Programme	Code Activity's																			
		Course	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	
FSEGN	QI	DMAIC methodology											1				1				
		Lean Management									1						1				
		Statistical Process Control											1								
		Tutored project																1			
INSAT	BC	Intelligent methods and applications					1		1					1							
		Computer-Assisted-Production Management	1	1	1		1	1	1												
	IMI	Data Transmissions											1	1	1						
		Industrial Information Systems: ERP & SAP			1		1								1			1			
		Production Logistics & Industrial Organization			1	1	1				1	1				1	1	1			
		Industrial Control & Supervision					1					1			1	1					
		Industrial Automation										1		1	1	1		1			
		Real-Time Computing	1		1								1	1							
		Modelling Analysis and Performance Evaluation		1								1				1		1		1	
		Industrial networks & Sensor Networks			1									1	1						
		Logistics Chain & flow control			1	1	1				1	1			1	1	1				
		Scheduling	1	1	1		1														
		Integration and Management of Industrial Systems												1	1	1		1			
		Industrial Performance Monitoring											1			1	1		1		
		IIT	IE	Production and Inventory Management						1	1	1									
				Planning and Scheduling	1	1	1	1	1												
				production systems design										1						1	
Simulation of industrial systems																	1		1		
Supply Chain Management																1					
UIT	M.ERP	Production management	1	1	1																
		Production monitoring														1	1	1			
	ILE	Production Management	1		1											1					
		Horizontal and vertical integration														1	1	1			
ECC		Operation management	1	1	1	1	1	1	1								1				
		Operation's mathematical and computing tools	1		1	1	1	1	1								1				
		Sustainable Dev & Circularly Economy	1			1				1											
		Queues' theory																			
<b>Statistics</b>			<b>9</b>	<b>6</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>4</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>7</b>	<b>4</b>	<b>6</b>	<b>7</b>	<b>1</b>	<b>1</b>	<b>9</b>	<b>2</b>	<b>2</b>	

Table 4 List of priority courses related to Quality topic to be updated /created

Quality																
HEI	Programme	Activity	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12		
		Course														
FSEGN	QI	DMAIC methodology		1		1	1									
		Quantitative techniques							1							
		Lean Management	1													
		Statistical Process Control		1	1	1				1						
		Tutored project		1				1	1	1					1	
INSAT	BC	Intelligent methods and applications										1				
		Computer-Assisted-Production Management										1				
	IMI	Computer-Assisted-Maintenance Management										1				
		Management Tools of Quality Control		1		1		1					1	1	1	
		Industrial Information Systems: ERP & SAP	1					1								
		Production Logistics & Industrial Organization						1	1							
		Industrial Control & Supervision						1	1							
		IIA	Industrial Automation						1							
	Modelling Analysis and Performance Evaluation							1	1			1				
	Industrial networks & Sensor Networks							1								
	Logistics Chain & flow control							1	1			1				
	Scheduling											1				
	Integration and Management of Industrial Systems		1						1							
	Industrial Performance Monitoring							1	1					1	1	
	IIT	IE	Internal Control and Procedures		1							1	1	1		1
			Statistical Quality Control			1	1	1	1	1	1				1	1
	UIT	M.ERP	In-process product quality control		1	1	1	1								
Quality management			1							1	1					
ILE		Quality management														
	Post-manufacturing quality control															
ECC		Lean Six Sigma				1										
<b>Statistics</b>			<b>4</b>	<b>6</b>	<b>3</b>	<b>5</b>	<b>1</b> <b>2</b>	<b>9</b>	<b>5</b>	<b>2</b>	<b>7</b>	<b>2</b>	<b>3</b>	<b>5</b>		

## 5. List of common courses and use cases to be developed

Using the selection rules given in section 3, and statistics given in *Table 2* to *Table 4*, all partners define, by the “selection process S4” (Figure 2) a list of six common courses (two per topic of MPQ4.0) and three use cases (one per MPQ4.0 topic). These common courses and use cases are populated by forty-three MPQ4.0 training activities (4 or 5 per course and 4 or 5 per use case). Most of the involved M&T-HEIs are interested in these common courses and use cases since they will contain the most requested training activities. The latter will be used to update the selected priority existing courses to update or new courses to create. By doing so, we have a guarantee to respond to some of M&T-HEIs’ skills development needs, which were highlighted by the gap analysis in task T1.2.

*Table 5* gives the content of each one of the common courses and use cases. It also shows the number of existing courses or new ones which will integrate these activities as well as the number of programs that will be affected. As we can notice in this table, the most of selected activities will have an important impact on almost all of M&T-HEIs’ programs.

Let’s emphasise here, that at this point we only define the contents of six common courses and use cases; all the related MPQ4.0 training material will be developed, by a common effort of all partners, later in the WP2 work package. Furthermore, these courses and use cases will be implemented in the designed MPQ4.0 learning Framework. They will be used in training trainers’ sessions in the short term, as will be described later in section 6. In the long term, they will be exploited by M&T-HEIs trained trainers, as individually imported activities to update their priority existing courses or to create the new ones, or as entirely imported course or use case, to update their programs’ content (Figure 2).

*Table 5. Final List of common courses and use cases to be developed*

	Course/Use case	Activities	Course		Program	
			nb	%	nb	%
Maintenance 4.0	Course 1 Advanced Maintenance strategies	Act 1.1 Use cases of eXtended Reality (XR) in Smart Maintenance 4.0 contexts	7	9,0	4	57,1
		Act 1.2 Sensor Network Design in Smart Maintenance 4.0 contexts	8	10,3	3	42,9
		Act 1.3 Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 context	10	12,8	2	28,6
		Act 1.4 Contributions of Smart Maintenance 4.0 to Energy Management & Energy Efficiency of Industry 4.0 Assets	6	7,7	3	42,9
		Act 1.5 Sustainability Driven Smart Maintenance 4.0	7	9,0	3	42,9
	Course 2 Integrated maintenance planning	Act 2.1 Data-Driven Reliability for Smart Maintenance 4.0	9	11,5	2	28,6
		Act 2.2: Maintenance planning and scheduling	15	19,2	3	42,9
		Act 2.3 Contributions of Industry 4.0 technologies to Total Productive Maintenance	4	5,1	4	57,1
		Act 2.4 Downtime forecast and optimal maintenance planning	16	20,5	3	42,9
		Act 2.5 Industry 4.0 Asset & Maintenance Management Systems	4	5,1	2	28,6
	Use case	Act U.1.1 Real-time communication	10	12,8	5	71,4
		Act U.1.2 Data acquisition and storage in industry 4.0	4	5,1	3	42,9
		Act U.1.3 ML and application for maintenance	9	11,5	6	85,7
Act U.1.4 KPI, Dashboarding and data visualisation		9	11,5	2	28,6	

	Course/Use case	Activities	Course		Program	
			nb	%	nb	%
<b>Production 4.0</b>	Course 1 Production, planning, scheduling and control in industry 4.0	Act 3.1: Design and development of smart Production Planning/Scheduling systems	22	28,2	4	57,1
		Act 3.2: Planning and scheduling techniques and approaches in industry 4.0	23	29,5	5	71,4
		Act 3.3: Methods and frameworks for control systems in agile manufacturing	22	28,2	4	57,1
		Act 3.4: Data-driven planning/scheduling models and algorithms	15	19,2	4	57,1
		Act 3.5: Big data and predictive inventory analytics	16	20,5	3	42,9
	Course 2 Factory 4.0: Concepts, techniques, and application	Act 4.1: PLM and Digital Factory	16	20,5	4	57,1
		Act 4.2: VSM for production 4.0	21	26,9	6	85,7
		Act 4.3: Virtual Reality for simulation	15	19,2	6	85,7
		Act 4.4: KPI, Dashboarding and data visualisation	4	5,1	2	28,6
	Use case	Act U.2.1 Emerging uses of smart technologies for production planning and scheduling	19	24,4	5	71,4
		Act U.2.2 Horizontal and vertical integration & Workflow management	15	19,2	4	57,1
		Act U.2.3 CPS design and development	5	6,4	2	28,6
		Act U.2.4 Data-driven inventory management	25	32,1	3	42,9
		Act U.2.5 Digital control systems (DCSs)	0	0,0	0	0,0

	Course/Use case	Activities	Course		Program	
			nb	%	nb	%
<b>Quality 4.0</b>	Course 1 Advanced PSS Quality Design	Act 5.1: Integrated thinking system modelling and development	4	5,1	3	42,9
		Act 5.2: Non-Conformities RCA and Quality gates design	8	10,3	3	42,9
		Act 5.3: QC model design	6	7,7	5	71,4
		Act 5.4: Design for X applied for Quality	20	25,6	5	71,4
		Act 5.5: IoT and BPM for Integrated VSM	10	12,8	4	57,1
	Course 2 QC analytics for Zero defect manufacturing	Act 6.1: Integrated process improvement	4	5,1	2	28,6
		Act 6.2: Quality Process maturity self-assessment and lifecycle management	8	10,3	4	57,1
		Act 6.3: Inspection Methods, sampling, Inspection Plan	3	3,8	2	28,6
		Act 6.4: Prescriptive and adaptive decision for Quality Control	12	15,4	5	71,4
		Act 6.5: Quality Planning, Control and Management functions	2	2,6	2	28,6
	Use case	Act U.3.1 Sensors' sensitivity analysis and selection	5	6,4	4	57,1
		Act U.3.2 Non-Conformities RCA and Quality gates design	8	10,3	3	42,9
		Act U.3.3 IoT and BPM for Integrated VSM	4	5,1	3	42,9
		Act U.3.4 Process maturity self-assessment and lifecycle management	12	15,4	5	71,4
		Act U.3.5 Prescriptive and adaptive decision for Quality Control	8	10,3	4	57,1

## 6. Training Activities orchestration

Each one of the common six courses and three use-cases defined in section **13** is composed of 4 or 5 MPQ4.0 training activities, and it addresses a specific topic.

Each training activity targets certain skills related to the course's topic. It will be designed as a collection of tasks. This decomposition of each activity in tasks gives a small granularity which offers trainers in M&T-HEIs more flexibility to effectively update existing courses or to create new ones according to training needs.

Thus, these MPQ4.0 courses and use cases will be developed later in the WP2 work package of the ENHANCE project, and be implemented in the developed LF-4.0 platform; The definition of tasks in each training activity will be done also in WP2.

As it is illustrated in Figure 3, there are three possible uses, in the long term, of the developed training activities/Courses/Use-cases, by trained HEI staff, to update HEI's programs. Figure 3 shows that the integration of developed training material can be made on two levels:

1. Common course or use case: in this case, the entire common course or use case is entirely integrated as it is in an HEI program.
2. Training activity: in this case, only some training activities from common courses or use case will be integrated into an existing course to be updated or a new one to be created.

It is up to each trained HEI staff to decide what they need to import from the common developed courses and use cases, to update their programs smoothly and progressively.

Let's emphasise here that all developed training materials as six common courses and three use cases, can be used by the trained HEI staff (trainers) in:

- an academic training by integrating some training tasks or training activities into the existing courses of the M&T-HEIs' programs to update, or eventually by integrating a one or more course(s) and/or one or more-use cases or create a new course(s) combining some activities according to training objectives.
- a training session of active staff (SMEs staff for example), as an on-demand training session or a self-training, by integrating and orchestrating developed training activities in a specific training track according to active staff's training needs.

Let's emphasise here that some of the developed MPQ4.0 training activities can be complementary or dependent; furthermore, they can necessitate prerequisites which must be acquired from other existing courses in M&T-HEIs' programs, and must therefore be orchestrated in a certain pedagogical and incremental order. Since M&T-HEIs' programmes are heterogeneous and their training objectives are more or less different, each trainer who wants to use these developed MPQ4.0 training activities to update some existing courses or create new ones has to do this orchestration itself according to training objectives and targeted trainees' profile.

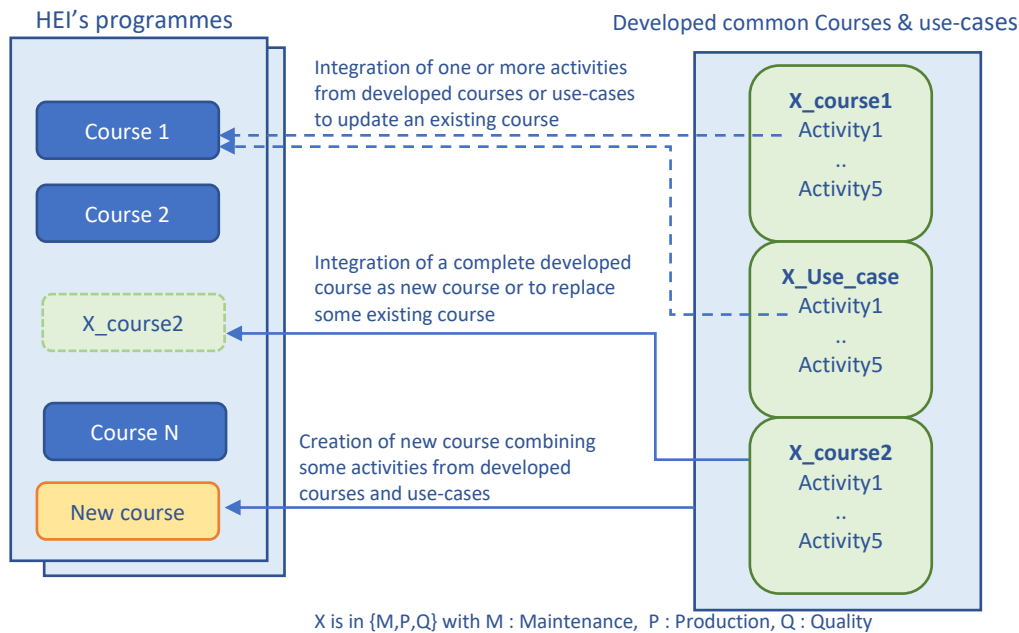


Figure 3–Possible use of the developed Courses/Use cases to update Existing HEIs Courses/Programs

## 7. HE staff training sessions

### 7.1. Training sessions

As a capacity-building project, ENHANCE project aims, using the developed MPQ4.0 training activities in work package WP2, to organize three types of training which are (Figure 4):

- Training sessions of trainers from HEIs involved in the project.
- Training sessions of students from HEIs involved in the project.
- Training sessions for active staff.

The HE staff training sessions are the most important, and it is the first conducted as it is illustrated in Figure 4. These three types of training sessions will be useful to improve the developed MPQ4.0 training activities before adopting them for long-term use in HEI by the trained HE staff.

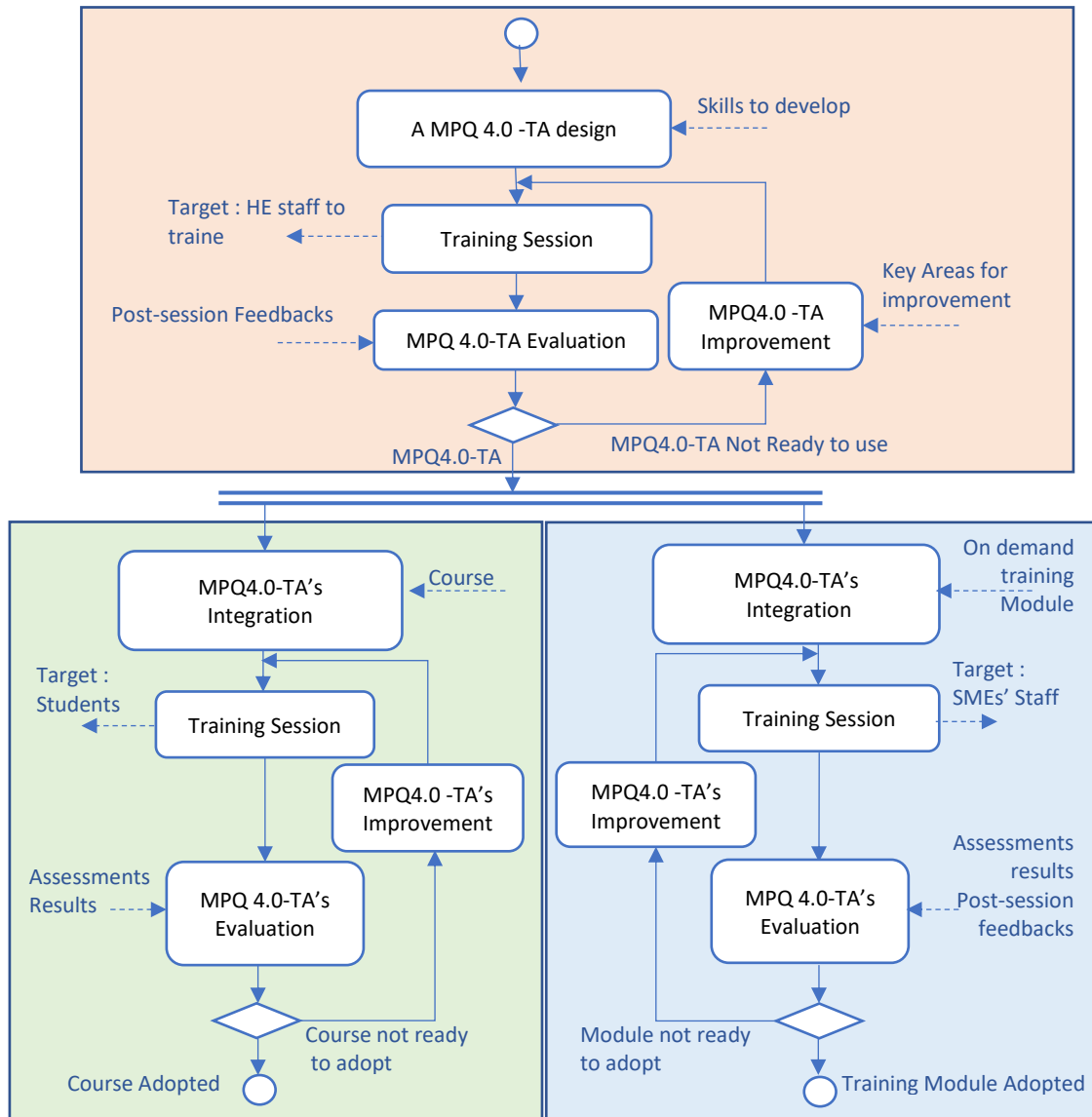


Figure 4– Types of training sessions in short term conducted by ENHANCE project

## 7.2. Planning of HE Staff training sessions

When the training materials of the selected MPQ4.0 training activities have been developed by a joint effort of all project partners, and when the equipment has been acquired, training sessions for trainers will be organized. The knowledge and know-how could be transmitted to the greatest number of HEI staff (trainers), to guarantee greater dissemination and a fairly significant impact on the existing programs of the HEIs involved in this project. It should be emphasized here that the training sessions are not limited to the trainers involved in this project, on the contrary, they will be open to any trainer interested in some or all of these training activities and wishing to integrate them into the training she/he provides. Let's recall that some trainers from HEIs staff, that were not directly involved in this project, have participated in task T1.2 to determine the course to be updated and to select the training activities for which they were interested.

These training sessions should provide initial feedback on the quality of MPQ4.0 training activities and their effectiveness in helping to reduce the gap, initially identified, between what exists and what is

desired in the area of MPQ4.0 knowledge and know-how. This feedback will certainly be used to review and improve the developed MPQ4.0 training activities as illustrated in Figure 4. This will be done by analysing data from post-session feedback and also from discussions with trained HE Staff.

Three trainers will be selected from partner UCAR, two from partner IIT, two from partner ECC and two from partner UIT and will be involved in the 3 MPQ pilots to train other trainers (M&T HEIs staff). This will be done during the project. Then, trained trainers will train students and some active staff (SME staff).

### 7.3. Scheduling of the training sessions

The training sessions will be scheduled in the organized meetings after training activities development and taking into account the expressed training needs by M&T-HEI staff. These sessions are related to training activities developed for the three pilot Maintenance, Production and Quality. They should match the interest of each M&T-HEI staff in integrating the contents of these training activities into the courses they provide. The proposed training of trainer session scheduling is given in *Table 6*.

*Table 6. Scheduling of the training sessions*

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

### 7.4. Evaluating training activities for Refinement/Improvement

After each round of training of trainers (M&T- HEIs staff), an evaluation of each training activity will be done. This evaluation process will be broken down into the following steps:

- Collection of post-session feedback from trainees (M&T- HEIs staff).
- Reflection on own training and participant feedback post activity.
- Identification key areas for improvement in activities conducted.

Post-session feedback will be collected using as:

- forms of a questionnaire filled by trained trainers: they will be used to measure principally:
  - the added value provided by each training activity to reduce the gap between skills initially targeted by M&T-HEIs programs and skills that are required by industry4.0, particularly in topics of maintenance, production and quality.
  - the adequation of training activity to be integrated into existing courses and use cases taking into consideration current objectives of M&T-HEIs programs, 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), and complete and update the provided training activities in the future to guaranty to ENHANCE project certain sustainability, then discussion with these trainers will be beneficial to improve the developed training activities.



After this evaluation process of each training activity, used in one or several trainers' training sessions, follows a refinement/improvement process of the training activity.