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Capacity Building in the field of Higher Education

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

D1.4. Design of training strategy for partner HE staff

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Executive Summary

The purpose of D1.4 is to describe the strategy followed in order to select from the current curricula of HEI the MPQ4.0 courses that may be enhanced and to define new courses that will be used by the HEI to enhance their current curricula. The different activities to use for the modification of current courses or the creation of new ones are selected from the list proposed at the end of Task 1.2.

As a CBHE project, the ENHANCE vision is organised around five main pillars:

- The European vision about Maintenance, Production, and Quality engineering in the context of industry 4.0 (MPQ4.0). The programme country members synthesise the most impacting related work in MPQ 4.0, share the best practices of the teaching programmes in their institutions and finally, their Digital Innovation Hubs (DIHs) services and experimented solutions.
- The partner countries vision about the existing teaching programmes in the involved Tunisian and Moroccan universities. This vision is completed with current practices and new MPQ 4.0 requirements collected from selected industrial partners in different application domains.
- The MPQ 4.0 Learning Framework to cover the gaps and draw the path for training the trainers in the three main topics.
- The MPQ 4.0 pilots' development to create effective skills, competencies, technology acquisition channels to support digital transformation in the industry. The generated materials are to be structured in the Longlife eLearning (LeL) platform to be deployed at each partner countryside.
- The creation of 2 DIHs, one in Tunisia and one in Morocco to sustain the ENHANCE outcomes and organise their exploitation model to support MPQ 4.0 industrial challenges in both countries.

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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.

2. Introduction

As the enhance project aims to develop new training capacities at Higher Education Institution (HEI) in Tunisia and Morocco in the field of maintenance, production and quality, the HEI should be able to support this development. Some scientific contents related to MPQ4.0 should be provided to the trainees as training activities and/or courses. The theoretical contents should be enhanced by some practical works using dedicated equipment. The equipment acquisition, the development of learning materials (course files) and scientific contents and how they can be embedded into the current programs as well as the training of trainers are among the challenges of this project.

2.1. Purpose of the document

The purpose of this document is to define the training strategy that permits to define the scientific contents to develop in order to update the current programs of HEI with respect to MPQ4.0 knowledge and technologies. That is represented by the set of activities that may be considered to extend the current courses and to create new ones dedicated to students and industrial staff. More precisely, this strategy will help from one side each HEI to define which courses will be modified and which activities to use for that, and from another side, it will help all partners to define together the contents of six common courses, two courses by domain, that will enhance the current programs.

2.2. Reference documents

This document will be based on the deliverable D1.2 interesting to analyse the gap between the knowledge developed actually in HEI and what should be developed for MPQ4.0.

2.3. Applicability

This document presents the different steps followed to help each HEI to select from the current educational programs the courses to modify and the activities to use for this development. At the end of each step, the list of choice made by the HEI will be presented.

2.4. Definitions

In the following, the main concepts used in this document are briefly explained:

- **Activity:** represent a scientific content that can be developed as a part of a new course or a session to add to a current course to cover some skills. It can be developed also as a case study.
- **important Activities:** it is the set of activities that can interest all the HEI to enhance at least one program per HEI and can be used to develop common courses
- **Priority courses:** these are the current courses in the HEI programs that should be updated before any other courses. This priority is defined by the different partners.
- **Common courses:** these are the courses that will be developed in work package 2 to be given by all the HEI for students and industrial staff. The activities that constitute these courses are selected in task 1.4 by all the HEI.

2.5. Structure of the document

This document starts by giving an overall view of the training strategy by presenting its different steps. After that, in section 2 and 3, all the steps are presented with more details and described each one separately. In section 4, the different activities proposed in Task1.2 are presented. The first selections of courses and activities is presented in section 5. Section 6 is dedicated to analysing the different choices in order to detect the most requested activities. Section 7 concerns the selection of priority courses and the associated activities and finally, section 8 concerns the definition of common courses with the selection of the dedicated activities.

2.6. List of acronyms

- MPQ – Maintenance Production Quality
- HEI : Higher Education Institution
- PC : Partner Countries
- FMECA : Failure mode, effects, and criticality analysis
- SMED : single-minute exchange of die
- SD : Standard deviation
- CMMS : Computer maintenance Management System
- CBM : Condition Based maintenance
- PHM : Prognostic Health Management
- MTBF : Mean Time Between Failures

3. Training strategy for partner HEI staff

This section presents the suggested strategy to develop MPQ 4.0 skills. This strategy should lead to achieve the main following goals.

- Identify the list of courses (from the existing ones) that will be revised/updated for each of the seven considered curricula (already presented in the deliverable D1.2 - Gap analysis between HEIs and industry 4.0 skills related to MPQ4.0).
- Identify six new courses (two courses for Maintenance, two courses for Production and two courses for Quality) that will be developed for all the seven considered curricula.

The suggested strategy is based on the steps presented in figure 2. These steps are explained in the following:

- **Step 1 - Analysis of the identified gaps and proposition of activities:** the training strategy starts by analysing the identified gaps presented in the deliverable D1.2 - Gap analysis between HEIs and industry 4.0 skills related to MPQ4.0. The objective of this analysis is to define different processes for each topic (Maintenance, Production and Quality) that should be developed to bridge the identified gaps. The analysis of the identified gaps will lead to the identification of a preliminary list of activities that need to be implemented and that will be refined in the following steps. These activities will be classified by topic and can be considered to extend existing courses or to develop new ones. These activities are defined based on the targeted skills as well as the partners HEI requirements to develop those skills for students and industrial staff.

- **Step 2 – Selection of courses to be revised and assignment of activities:** in this step, each PC HEI will select the list of courses that may be updated/revised. The identified courses should be in relation with identified gaps (i.e., MPQ processes discussed in D1.2- Gap analysis between HEIs and industry 4.0 skills related to MPQ4.0). Moreover, activities identified in step 1 are assigned to identified courses. In this step, all concerned teachers are involved to guarantee a successful implementation of the activities. There is no restriction on the number of courses and activities that will be selected as the list will be refined in the next steps.
- **Step 3 – Selected Activities analysis:** this step consists in identifying the activities selected by most of HEI or curricula. Such information about these activities may be helpful to extend the current courses and to develop the new common ones.
- **Step 4 – Identification of the priority courses:** in this step, the first list of courses and activities must be revised to identify the priority courses to update. The selection of the priority courses will facilitate later the implementation of the activities. Indeed, some constraints related to each partner should be considered in this step.
- **Step 5 – Definition of new courses to be developed:** The objective of this step is the definition of the six new courses that will be implemented. Indeed, one of the expected outcomes of the project is the development of six new courses (two courses for Maintenance, two courses for Production and two courses for Quality). These six courses will be developed for the seven curricula in work package 2.

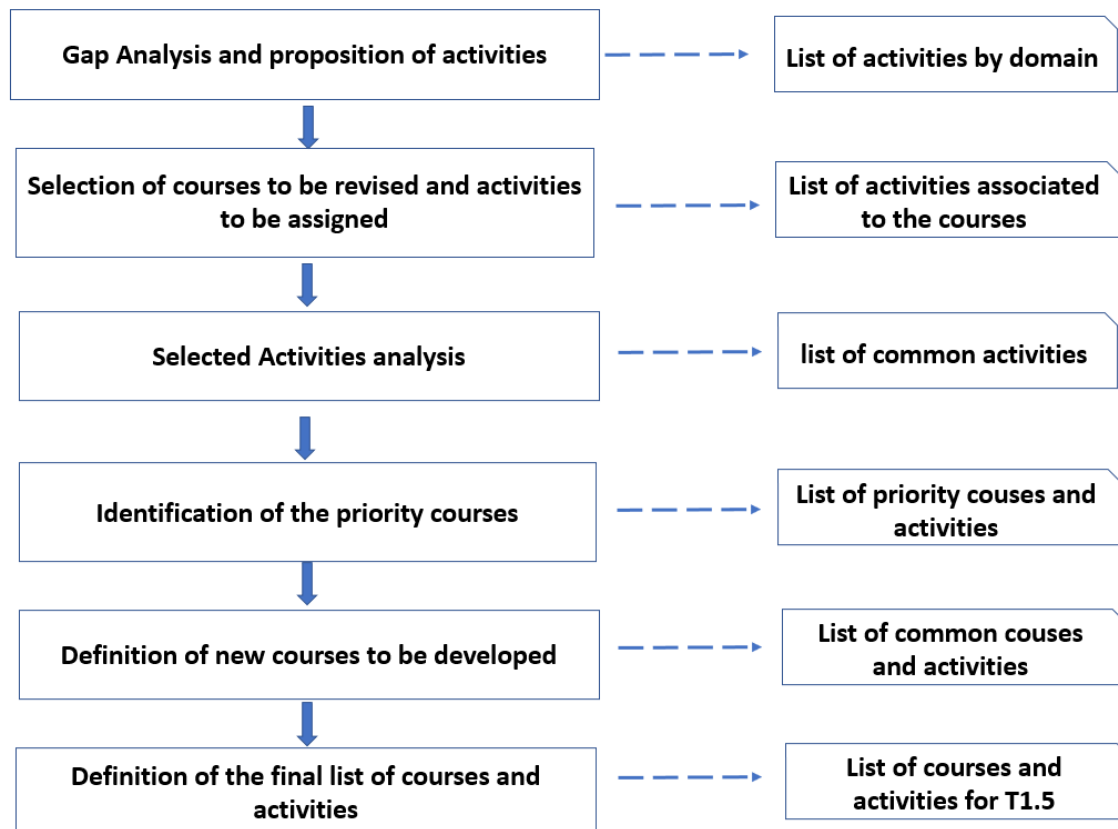
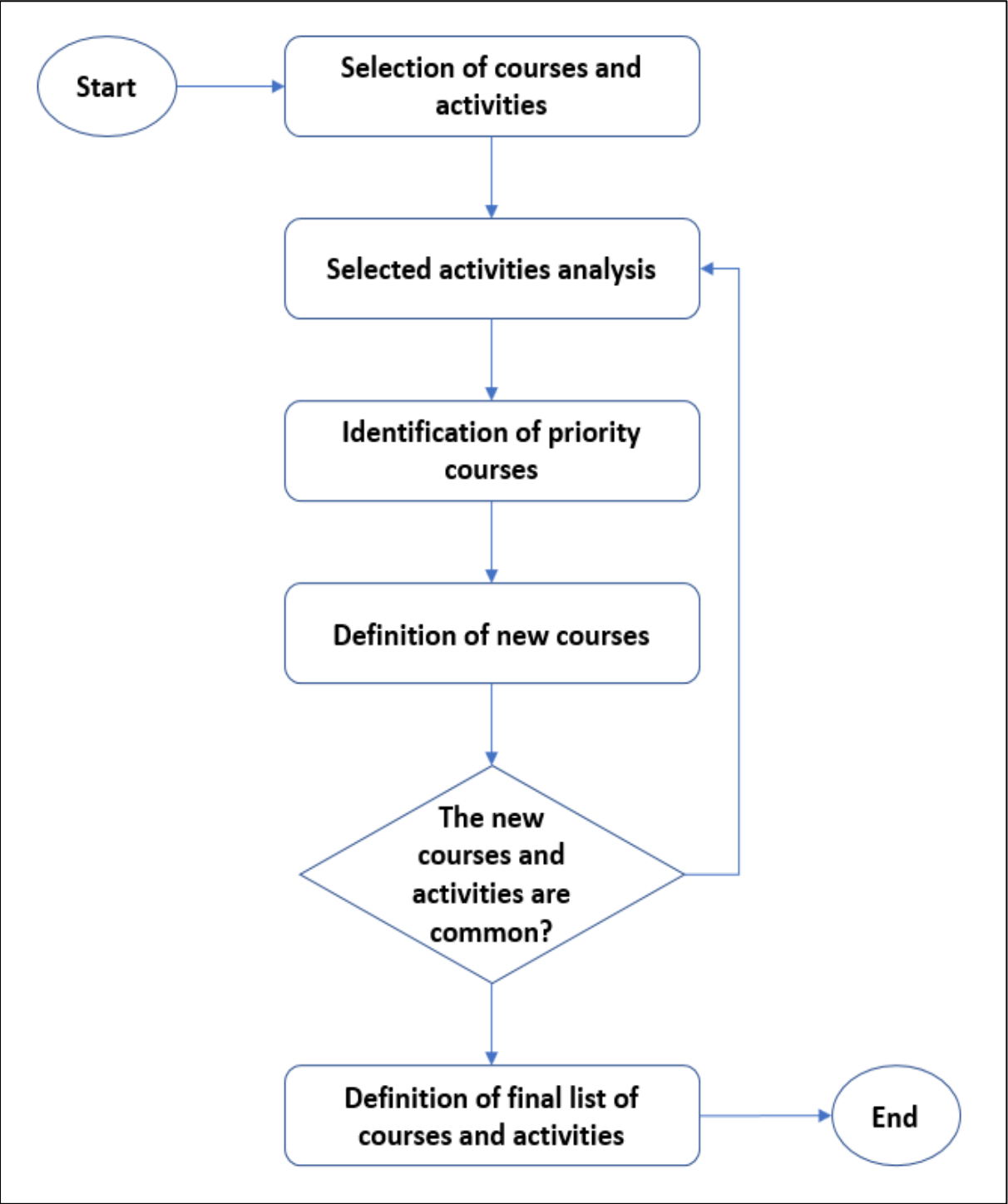


Figure 2 - Training strategy diagram

As the objective is to create common new courses with common activities to enhance existing programs, some steps may be repetitive to find common meeting points between all partners. The following flowchart (figure 3) shows the repetitive steps and gives more explanation regarding the training strategy.



4. Analysis of the identified gaps and proposition of activities:

For each topic, several activities are proposed in this step. To prepare the first list of activities, a document has been shared between partners. Each partner is asked to suggest the activities that he consider interesting and that may tackle to identified gaps in D1.2. Each activity represents a content to be used to update an existing course or to create new ones.

After collecting the set of activities, they are classified according to specific MPQ4.0 processes that are identified in the document “D1.2-Gap analysis between HEIs and industry 4.0 skills related to MPQ4.0”. Table 1, 2 and 3 present the list activities by topic. For maintenance 4.0, the considered processes are: corrective maintenance, preventive maintenance and predictive maintenance. Concerning production 4.0, the considered processes are: planning and scheduling, inventory management and production monitoring and control. Finally For quality 4.0, the considered processes are: in-process product quality control, post-manufacturing quality control and quality management.

Table 1 Training activities for Maintenance 4.0

Corrective maintenance		Preventive maintenance		Predictive maintenance	
Code	Activities	Code	Activities	Code	Activities
MC1	Lean Maintenance : tools preparation, organisation and management	MPrev1	PM Task Lists	MPre d1	Identify critical assets
MC2	5S, SMED	MPrev2	Breakdown Costs	MPre d2	Establish a data base (CMM'I'S, ...)
MC3	Organization and preparation of disassembly	MPrev3	Calculate the Standard Deviation (SD)	MPre d3	Analyse failure modes (RCM, FMEA, ...)
MC4	Inspection, verification, sampling, measurement	MPrev4	Using MTBF for Failure Analysis	MPre d4	Implement CBM, PHM
MC5	Organization and preparation of reassembly	MPrev5	Specific CMMS Training	MPre d5	Develop predictive models and algorithms
MC6	XR for disassembly, inspection/verification and assembly	MPrev6	PM Reliability Enhancement: FMECA, Reliability Cantered Maintenance to PPM, PM Optimization, etc.	MPre d6	Deploy to pilot equipment
MC7	Refurbishment	MPrev7	Sustainability driven maintenance	MPre d7	Real time communication
MC8	Restart and Ramp up after breakdown	MPrev8	CMMS dashboards and reporting functions	MPre d8	Big data processing and modelling techniques
MC9	Design of Experiments (DOE) to optimize system parameters for restart/ramp up	MPrev9	Maintenance planning and scheduling	MPre d9	Downtime forecast and optimal maintenance planning
		MPrev10	Total Productive Maintenance and Industry 4.0 technologies	MPre d10	Data acquisition and storage in industry 4.0

	MPrev1 1	Facilities and Utilities: Energy Efficiency	MPre d11	Predictive maintenance sensors and implementation
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Table 2 Training activities for production 4.0

Planning and scheduling		Inventory management		Production monitoring and control	
PPS1	Planning and scheduling techniques	PIM1	Finance, Supply Chain, Procurement, Customer Service, Warehouse Management	PPMC1	Real-time data acquisition
PPS2	Master Production Scheduling (MPS)	PIM2	Cloud-based inventory management : process, classification, system parameters and system review	PPMC2	Knowledge-based systems
PPS3	Capacity and Materials Requirements Planning	PIM3	Demand planning and forecasting techniques and models	PPMC3	Data fusion and analytics
PPS4	Emerging uses of smart technologies for production planning and scheduling	PIM4	Big data and predictive inventory analytics	PPMC4	IoT/CPS development and integration
PPS5	Horizontal and vertical integration & Workflow management	PIM5	Business process, KPI & Reporting	PPMC5	Interoperability, visibility, connectivity,
PPS6	Design and development of smart Production Planning/Scheduling systems and processes	PIM6	Inventory management dashboards	PPMC6	distributed / digital control systems (DCSs)
PPS7	Planning and scheduling techniques in industry 4.0 and cloud manufacturing	PIM7	Inventory locating tracking and moving	PPMC7	PLM and Digital Factory to model and act the physical system
PPS8	Data-driven planning/scheduling models and algorithms	PIM8	Spare part inventory management	PPMC8	Lean production under Industry 4.0 paradigm
PPS9	Cyber Physical Production Systems design, assessment, evaluation models and security	PIM9	Emerging uses of smart technologies for Material Handling Systems (internal logistics, storage, etc.)	PPMC9	Automated Value Stream Mapping
PPS10	Digital transformation in production planning and scheduling	PIM10	Collaborative inventory management (VMI, ECR, etc.)	PPMC10	Design of facility layout for Industry 4.0
PPS11	Planning & Scheduling of robotic & cobotic systems (shared resources, assignment problems, line balancing, etc.)	PIM11	Lean inventory control	PPMC11	Virtual Reality to simulate industrial process
PPS11	IT 4.0 infrastructures and knowledge management			PPMC12	Production Control Systems: KANBAN, (X-

)CONWIP, POLCA, COPACABANA, REDUTEX, etc.
PPS12	Data governance and security		PPMC13	Simulation & Digital Twins
PPS13	Process modelling for industry 4.0		PPMC12	Emerging uses of smart networks and services
			PPMC13	Smart factory connectivity and communications
			PPMC14	Decentralization, autonomous decisions and autonomy
			PPMC15	Networks for CPS and industrie 4.0
			PPMC16	Real time operating cyber-physical systems
			PPMC17	Emerging uses of industry 4.0 technologies for Occupational Health, Safety & Ergonomics

Table 3 training activities for quality 4.0

In-process product quality control		Post-manufacturing quality control		Quality management	
QInC 1	Non-Conformities RCA and Quality gates design	QPmC 1	Metrology Basics: metrology, inspection, accuracy and precision, etc.	QQM1	Digitalization of quality management systems
QInC 2	Sensors' sensitivity analysis: digital, analogical	QPmC 2	Generic quality control tools	QQM2	business process management -VSM
QInC 3	Sensors network setup and data accumulation	QPmC 3	Standards and Comparators: Line Standards, End Standards, Slip Gauges or Johanssen Gauges	QQM3	Quality Planning, Quality Control, IQM – Functions
QInC 4	QC model design	QPmC 4	The use of comparators	QQM4	Integration materiel management, Production Planning ,sales and distribution, ...
QInC 5	Sensors network risks	QPmC 5	Measurement of Surface Finish	QQM5	Master Data
QInC 6	Design for X (resilience, agility, maintainability, sustainability, etc.)	QPmC 6	Machine Tool Testing: Alignment Tests on Lathe, Milling, Drilling machines	QQM6	Inspection Methods, sampling, Inspection Plan
QInC 7	Operational excellence 4.0	QPmC 7	Process maturity self-assessment	QQM7	Technologies and trends in Customer and Supplier Relationship Management in industry 4.0
QInC 8	real time quality control	QPmC 8	Integrated thinking system modelling and development	QQM8	Quality Info Records ,Lot Inspection, Result Recording, Usage Decision

	QPmC 9	Digitalization of Holistic Quality - Describing a holistic, integrated, system-wide approach	QQM9	KPIs, Dashboarding and Reporting
	QPmC 10	Integrating Lean Manufacturing into Industry 4.0 – JIT, Kanban, TPM concepts in Industry 4.0		
	QPmC 11	Continuous Improvement of Performance		

5. Selection of courses to be revised and activities to be assigned:

This step consists in defining the list of courses to modify for each studied program (7 programs, see D1.2) as well as the list of assigned new activities. The partners are asked at the first time to select from the list of courses of each curricula the courses related to maintenance, production and quality that need to be updated. Then in a second round, partners are asked to assign to them a set of new activities from the list identified in step 1 (see section 4). The list of courses selected by each institution as well as the activities to add to them are presented in the tables 4 to 10.

These tables show the importance of some activities for partners. Indeed, we can notice that some activities have been selected several times for several courses and sometime for the same program. Although, the assignment of activities to courses has been defined by the representatives of each institution in coordination with the responsible of courses and programs, the integration of these activities seems difficult regarding some constraints related to current trainers' qualification, resource availability as well as the amount of workload allowed for each course and activity. The high number of courses and activities presented in these tables make the modifications more difficult. For that, this first list should be discussed and analysed to focus on most important and most requested activities which may help later the modification of the requested courses.

Table 4 First selection of courses and activities for IIT

List of selected courses	Maintenance 4.0 activities	Production 4.0 activities	Quality 4.0 activities
Maintenance management / CMMS	MPrev1 – MPrev11		
Reliability and Predictive Maintenance of systems	MPred1 – Mpred11		
Production and inventory management		PIM2, PIM4, PIM 6	
Industrial system engineering : planning and scheduling		PPS4, PPS6, PPS7, PPS9, PPS10	
Industrial system engineering : production systems design		PPMC 10, PPMC11	
Internal Quality Control			QPmC8 to 11
Statistical Quality Control			QInC1 – QinC7

Table 5 First selection of courses and activities for ECC

List of selected courses (FR)	Maintenance 4.0 activities	Production 4.0 activities	Quality 4.0 activities
S5 - Gestion de projets		PPS1, PPS4 -10,	QInC7, QPmC11,

		PIM5, PPMC2, PPMC4, PPMC8	QQM2
S6 - Introduction au Génie Industriel	MC1 to MC6, PMPPrev10, MPred3,	PPS4, 5, 6, 9 PPMC7, 8, 9 and 10	QInC6, 7 QPmC7, 10 QQM2
S7 - Gestion des opérations		PPS1 to 11, PIM1 to 9, PPMC1 to 13	QInC7, QPmC8 to 11 QQM1 to 6
S7 - Electif - Facteurs humains	MC1 to 8	PPS1, 3, 4, 9, 11 PPMC8, 17	QInC7 QPmC10, 11 QQM2
S8 - ISC - Systems Engineering	MC4, 6, 9,	PPS4, 5, 6, 9, PIM5 PPMC4, 10	QInC6 QPmC7 QQM6
S8 - Outils Maths & Info en Opérations		PPS1 to 11 PPMC10, 12, 13	
S8 - Prod. Developpement Durable Eco Circ	MC4 MPrev3, 4, 6, 7 MPred3, 5, 8 to 11	PPS1 to 11 PPMC10, 12, 13	QInC6
S8 - Théorie des files d'attentes		PPS1 to 11 PPMC10, 12, 13	
S9 - Modélisation d'entreprise		PPS5, 9, 10 PIM5 PPMC4	QInC6 QPmC7, 8, 9, 10 QQM2
S9 - Aide à la décision multi-critère		PPS4, 8 PIM9 PPMC3, 13	QQM9
S9 - Management de systèmes d'information	MPrev5, 8	PIM5, 6	QQM7, 8, 9
S9 - Simulation de systèmes industriels	MC6, 9 MPrev2, 3, 4 MPred5, 8	PPS1, 6, 7, 8, 10 PIM2 to 7, 9 PPMC1, 3, 7, 10 to 13	QInC6, 7 QPmC11 QQM2
S9 - Recherche opérationnelle		PPS1 to 11 PPMC10, 12, 13	
S9 - Management des achats		PPS3 PIM1 to 9 PPMC3, 12	QQM7
S9 - Management de la maintenance	MC1 to 9 MPrev 1 to 10 MPred1 to 11	PPS1, 4 to 8 PIM8 PPMC1, 3, 12, 13	QInC6, 7 QPmC10, 11 QQM2
S9 - Fiabilité des systèmes industriels	MC1 to 9 MPrev 1 to 10 MPred1 to 11	PPS4, 6 PPMC1 to 7, 13	QInC1 to 6, 8 QPmC1 to 6 QQM6, 8
S9 - Gestion des opérations hospitalières		PPS1 to 11 PPMC10, 12, 13	
S9 - Lean Six Sigma	MC1, 4, 9 MPrev3 MPred5	PPMC1, 3, 8, 12, 13	QInC1 to 8 QPmC1 to 11
S9 - Supply Chain Management		PPS1 to 11 PIM1 to 9 PPMC1 to 13	QInC7 QPmC8 to 11 QQM1 to 6

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Table 6 First selection of courses and activities for UIT- Industrial Engineering

List of selected courses (FR)	Maintenance 4.0 activities	Production 4.0 activities	Quality 4.0 activities
Démarche qualité et projets industriel tuteurés			QInC1 to 7 QPmC2, QPmC3, QPmC5 to QPmC9 QQM1, QQM4, QQM5 to 9
Planification et ordonnancement		PPS6, PPS7, PPS8	
Gestion de la production		PPS2, PPS4, PPS5, PPS7, PPS9, PPS10 PIM2, PIM4, PIM5, PIM6, PIM7 PPMC 1 to 11	
Maintenance industrielle et fiabilité	MC6 to 9 MPrev 4 to 10 MPred2 to 11		

Table 7 First selection of courses and activities for UIT- ERP ICL

List of selected courses (FR)	Maintenance 4.0 activities	Production 4.0 activities	Quality 4.0 activities
Fonction Suply Chain Et Son Environnement		PPS6, PPS7, PPS8	
Gestion de production, planification et exécution		PPS2, PPS4, PPS5, PPS7, PPS9, PPS10 PIM2, PIM4, PIM5 to 7 PPMC1 to 11	
Maintenance industrielle et fiabilite (ERP SAP PM)	MC6 to 9 MPrev 4 to 10 MPred2 to 5, MPred7 to 11		
lean manufacturing et SIX sigma			QInC1 to 7 QPmC2, QPmC3, QPmC5 to 9 QQM1, QQM4, QQM5 to 9

Table 8 First selection of courses and activities for UCAR - IMI

List of selected courses	Maintenance 4.0 activities	Production 4.0 activities	Quality 4.0 activities
Industrial Automation		PPS11 - PPS13 PPMC6 - PPMC1 - PPMC7 - PPMC11- PPMC14	
Data Bases	MPred2 - Mpred10	PPS11 - PPS12	

Maintenance Dashboard	MPrev7 - MPrev8	PPS13 PIM6	QInC7
Computer-Assisted- Production Management		PPS6-PPS7-PPS8-PPS10 PIM2-PIM4	
Computer-Assisted- Maintenance Management	MPrev5 - MPrev8 - MPrev9		
Data Transmissions		PPS11 - PPS12 PPMC1 - PPMC13	
Monitoring Thermal fluid installations		PPS13 PPMC2-PPMC8	QInC7 QPmC7- QPmC8- QPmC9-QPmC10- QPmC11
Industrial Networks & Sensor Networks		PPS7 PPMC1 - PPMC4 - PPMC6 - PPMC12- PPMC15	
Management Tools of Quality Control		PPS13	QInC1 QPmC2 - QPmC3 QQM1-QQM5-QQM6- QQM7
IT for Instrumentation		PPS11 PPMC2 - PPMC3 QPmC1-QPmC2	
Maintenance Diagnostic Tools & Techniques	MPred4to 11 MPrev6 - MPrev7		
Acquisition, Control and Interfacing Technologies		PPS11	QInC2-QInC3 QPmC4
CAD/CAM of Mechanical Systems		PPMC7 - PPMC11	
Industrial Information Systems : ERP & SAP	Mpred10	PPS7 - PPS10 - PPS13 PIM4 - PIM5 PPMC4 - PPMC5 - PPMC6 - PPMC11	QQM2
Real Time Systems		PPS5 PPMC3 - PPMC4- PPMC5 PPMC16	
Production Logistics & Industrial Organization	MPrev10	PPS11 - PPS13 PIM5 PPMC7 - PPMC8- PPMC9 - PPMC11	QPmC7 to 11
Industrial Control & Supervision		PPS11 - PPS13 PPMC1-PPMC5- PPMC7-PPMC9- PPMC14	

Table 9 First selection of courses and activities for UCAR - IIA

List of selected courses	Maintenance 4.0 activities	Production 4.0 activities	Quality 4.0 activities
Data Transmission		PPS11 - PPS12 PPMC1 - PPMC13	

Operation Research and Optimization		PPMC2-PPMC3	
Quality management and Industrial Performances		PPS13	QQM1
Industrial Process Control		PPMC6 - PPMC2 - PPMC3	
Industrial Automation		PPS11 - PPS13 PPMC6 - PPMC1 - PPMC7-PPMC11-PPMC14	
Data Bases	MPred2 - Mpred10	PPS11 - PPS12	
Operating Safety	MPred4 - MPred5- MPred9 MPrev7 - Mprev10	PPS12	
Quality tools and approaches	MC9		QInC1 QPmC2 - QPmC3 QQM2 - QQM5 - QQM7
Computer-Aided Production Management		PPS4	
Real Time Computing		PPS6 PPMC3 - PPMC4- PPMC5 PPMC16	
Image Processing and Vision		PIM4 PPMC2 - PPMC3 - PPMC11	
Modelling Analysis and Performance Evaluation		PPS5 - PPS8 PPS9 PPS10 PPS13 PIM4, PIM5, PIM7 PPMC7, PPMC9, PPMC11	
Industrial Networks & Sensor Networks		PPS7 PPMC1 - PPMC4 - PPMC6 - PPMC12	QInC4
Logistics Chain & flow control		PPS6 - PPS9 - PPS10 - PPS11- PPS13 PIM2-PIM5 - PIM6 - PIM7 PPMC2 - PPMC9 - PPMC10 - PPMC11 PPMC15	
Digital factory		PPS5, PPS9, PPS10, PPS11, PPS13, PPMC2, PPMC3, PPMC5, PPMC7, PPMC11	
Industrial Control and Supervision	MPred10 - MPred11	PPS11 - PPS13	

		PPMC1-PPMC5-PPMC7-PPMC9-PPMC14	
Scheduling		PPS6 to 8, PPMC3	
Industrial Information Systems (ERP/MES/CPS)	Mpred10	PPS7 - PPS10 - PPS13 PIM4 - PIM5 PPMC4 - PPMC5 - PPMC6 - PPMC11	QQM2
Soft Computing		PPMC2-PPMC3	
Integration and Management of Industrial Systems		PPS5 PIM2-PIM5 PPMC3-PPMC13	QQM2
Industrial Performance Monitoring		PPS11 - PPS13 PPMC2-PPMC3-PPMC8	QInC7 QPmC7- QPmC8- QPmC9-QPmC10- QPmC11
Decision Making and Risk Management		PPS11-PPS12 PPMC2-PPMC3	QInC5 - QInC6

Table 10 - First selection of courses and activities for UCAR – Master FSEGN

List of selected courses	Maintenance 4.0 activities	Production 4.0 activities	Quality 4.0 activities
DMAIC methodology	MPred3 MPrev9	PPMC1,PPMC9	QInC1, QInC4,QInC6
Quantitative techniques			QQM6
Lean Management		PPMC9, PPMC12	QQM2
Statistical Process Control	MPrev10	PPMC1	QInC1,QInC2,QInC4 QQM6
Tutored project	MPrev9	PPS7 PPMC12, PPMC1, PPMC11	QInC1,QInC4, QInC6 QQM6, QPmC7
Intelligent methods and applications		PPS8 PIM4 PPMC4	

6. Selected activities analysis

Based on the choices made in the previous step regarding the selection of activities and courses, we noticed that some activities are frequently selected. Some activities are also requested in all programs. Therefore, it is important to conduct a statistical analysis of activities selection made in previous step. Therefore, we calculate for each activity the number of times it has been selected to improve a course for a specific program. The number of selections for each activity is presented in tables 11, 12 and 13 and the important activities are then detected. In these tables, the green lines represent the activities selected by all institutions for all programs while the blue lines represent the activities selected by at least one program by institution. For instance, in the maintenance topic, the activities MPrev 9 and 10 and MPred 9 are selected by all HEI to be added to all programs while the activities MPrev 5 to 8, MPred 3 to 5 and MPred 1, 7, 8, 11 are selected for at least one program by HEI.

The same statistical analysis is made for the production activities. From table 12, we can note that the activities PPS7, PPMC9 and 11 are selected by all institutions while PPS6, PPS9, PPS10, PIM2, PIM 4, PIM 6, PPMC8, PPMC9 and 10 have been selected for at least one program by institution.

Concerning quality topic, we can also detect from table 12 the activities selected for all the programs as QInC1, QInC3 and QpmC7 and the activities selected for at least one program by HEI which is the case of QInC2, QInC4 to 7, QPmC2, QPmC3 and QPmC28 QPmC9.

This distinction of important activities will not oblige the PC HEI institutions to focus only on these activities, but it will be helpful to restrict the number of courses to update and to define the common courses.

Table 11 Number of selections by program for maintenance activities

activities	numb er of select ion	Programs						
		IIT	ECC	UCAR – IMI	UCAR – IIA	UCAR – FSEGN	UIT - Indus Eng	UIT - ERP – ICL
MC1	5	0	5	0	0	0	0	0
MC2	4	0	4	0	0	0	0	0
MC3	4	0	7	0	0	0	0	0
MC4	7	0	4	0	0	0	0	0
MC5	4	0	4	0	0	0	0	0
MC6	8	0	6	0	0	0	1	1
MC7	5	0	3	0	0	0	1	1
MC8	5	0	3	0	0	0	1	1
MC9	8	0	5	0	0	0	1	1
MC10	0	0	0	0	0	0	0	0
MPrev1	3	1	2	0	0	0	0	0
MPrev2	4	1	3	0	0	0	0	0
MPrev3	6	1	5	0	0	0	0	0
MPrev4	7	1	4	0	0	0	1	1
MPrev5	7	1	3	1	0	0	1	1
MPrev6	7	1	3	1	0	0	1	1
MPrev7	9	1	3	2	1	0	1	1
MPrev8	8	1	3	2	1	0	1	1
MPrev9	9	1	2	1	1	2	1	1
MPrev10	10	1	3	2	1	1	1	1
MPrev11	3	1	2	0	0	0	0	0
MPred1	3	1	2	1	1	0	0	0
MPred2	5	1	4	0	0	0	0	0
MPred3	7	1	2	1	0	1	1	1
MPred4	8	1	2	1	0		1	1
MPred5	10	1	5	1	0	1	1	1
MPred6	5	1	2	1	0		0	0
MPred7	7	1	2	1	0	0	1	1

MPred8	10	1	5	1	0	0	1	1
MPred9	10	1	2	1	1	3	1	1
MPred10	11	1	2	3	3	0	1	1
MPred11	8	1	3	1	1	0	1	1

Table 12 Number of selections by program for Production activities

Activities	Number of selection	Programs						
		IIT	ECC	UCAR -- IMI	UCAR – IIA	UCAR – FSEGN	UIT - Indus Eng	UIT - ERP – ICL
PPS1	11	0	11	0	0	0	0	0
PPS2	9	0	7	0	0	0	1	1
PPS3	9	0	9	0	0	0	0	0
PPS4	17	1	14	0	0	0	1	1
PPS5	17	0	12	0	3	0	1	1
PPS6	21	1	13	1	4	0	1	1
PPS7	21	1	13	1	4	1	1	1
PPS8	21	0	10	4	3	1	2	2
PPS9	18	1	11	3	1	0	1	1
PPS10	18	1	12	0	3	0	1	1
PPS11	24	0	7	8	9	0	0	0
PPS12	6	0	0	2	4	0	0	0
PPS13	16	0	1	8	7	0	0	0
PIM1	3	0	3	0	0	0	0	0
PIM2	11	1	4	1	3	0	1	1
PIM3	5	0	4	0	0	0	1	0
PIM4	11	1	4	2	3	1	0	1
PIM5	16	0	8	2	4	0	1	1
PIM6	10	1	5	1	1	0	1	1
PIM7	8	0	4	0	2	0	1	1
PIM8	4	0	4	0	0	0	0	0
PIM9	5	0	5	0	0	0	0	0
PIM10	0	0	0	0	0	0	0	0
PIM11	0	0	0	0	0	0	0	0
PPMC1	14	0	6	3	5	1	0	0
PPMC2	13	0	4	2	7	0	0	0
PPMC3	20	0	8	2	9	0	1	0
PPMC4	15	0	6	3	4	1	1	0
PPMC5	11	0	3	3	4	0	1	0
PPMC6	13	0	3	4	5	0	1	0
PPMC7	14	0	5	4	4	0	1	0

PPMC8	11	1	6	2	1	0	1	0
PPMC9	12	1	3	1	3	2	1	1
PPMC10	14	1	10	0	1	0	1	1
PPMC11	19	1	3	5	7	1	1	1
PPMC12	14	0	11	1	1	2	0	0
PPMC13	15	0	12	1	2	0	0	0
PPMC14	3	0	1	1	1	0	0	0
PPMC15	3	0	1	1	1	0	0	0
PPMC16	2	0	0	1	1	0	0	0
PPMC17	2	0	2	0	0	0	0	0

Table 13 Number of selections by program for quality activities

Activities	number of selection	Programs						
		IIT	EC C	UCAR – IMI	UCAR – IIA	UCAR – FSEGN	UIT - Indus Eng	UIT - ERP – ICL
QInC1	10	1	2	1	1	3	1	1
QInC2	7	1	2	1	0	1	1	1
QInC3	6	1	2	1	0	0	1	1
QInC4	9	1	2	0	1	3	1	1
QInC5	6	1	2	0	1	0	1	1
QInC6	14	1	8	0	1	2	1	1
QInC7	14	1	8	2	1	0	1	1
QInC8	2	0	2	0	0	0	0	0
QPmC1	4	1	2	1	0	0	0	0
QPmC2	8	1	2	2	1	0	1	1
QPmC3		1	2	1	1	0	1	1
QPmC4	4	1	2	1	0	0	0	0
QPmC5	5	1	2	0	0	0	1	1
QPmC6	5	1	2	0	0	0	1	1
QPmC7	13	1	5	3	1	1	1	1
QPmC8	12	1	5	3	1	0	1	1
QPmC9	13	1	6	3	1	0	1	1
QPmC10	13	1	7	3	1	0	0	0
QPmC11	11	1	6	3	1	0	0	0
QQM1	5	0	2	1	1	0	0	1
QQM2	13	0	8	1	3	1	0	0
QQM3	2	0	2	0	0	0	0	0
QQM4	3	0	2	0	0	0	0	1
QQM5	6	0	2	1	1	0	1	1
QQM6	10	0	4	1	0	3	1	1
QQM7	5	0	1	1	1	0	1	1
QQM8	3	0	1	0	0	0	1	1
QQM9	2	0	0	0	0	0	1	1

7. Identification of the priority courses

The aim of this step is to limit the number of courses to revise for each considered program as their number was relatively high in the second step (see section 5). Therefore, each partner is asked to sort the courses to modify according to an order of priority. The objective is also to find a link between the selected courses and associated activities which help to define the common courses in the next step. During the physical meeting at BIBA which was from 07/11/2021 to 13/11/2021, each partner has presented their priority courses and the selected activities. Some constraints related to the workload and how to use the technical material has been discussed. At the end of this discussion, each partner has a restricted list of courses (2 courses by program) considered as priority courses to update. The tables 14 to 16 present, for each topic, the list of priority courses by institution. Some partners extended only existing courses by adding activities as the case of IIT and UIT while other partners as ECC, UCAR and UIT (in the case of ERP – ICL program) wanted to develop some new courses not existing in the current programs.

Tables 14 to 16 present also the percentage of selected courses for each topic with respect to the total number of activities assigned to each course. For example, among 11 selected activities to update the course “Maintenance Management /CMMS” for industrial engineering program of IIT, there are 7 important activities (MPrev 4 to 6 and MPred 7 to 10) already selected by all other partners. The distinction of the important activities will help later to define the new common courses and their activities.

Table 14 - Priority courses for Maintenance 4.0

HEI	Programme	Module	Existing / New	Number of selected activities	important activities	Percentage of important activities
IIT	Inds Eng	Maintenance management / CMMS	Extend existing course	11	MPrev 7 - 10 MPred 4 - 6	63%
		Reliability and Predictive Maintenance of systems	Extend existing course	11	MPred 3-5, 7-8,9 - 11	72%
UIT	Indus Eng	Maintenance industrielle et fiabilité	Extend existing course	17	MPred 4-6, 7 - 10	41%
	ERP - ICL	Maintenance industrielle et fiabilité (ERP SAP PM)	Extend existing course	4	MPred 3-5, 7-8	100%
UCAR	IMI	Maintenance Diagnostic Tools & Techniques	Extend existing course	10	MPred 5- 7 - 10, MPred 3-5, 7-11	80%
	IMI	Predictive maintenance (Data acquisition, sensors, IA, etc)	New Course			

	IMI	Advanced Maintenance Planning	New Course			
ECC		S9 - Management de la maintenance	Existing Course	31	MPrev 4-6, 7 - 10	22%
		S9 - Fiabilité des systèmes industriels	Existing Course	31	MPred3 – 5 , 7 – 8, 9 - 11	25%
		Virtual Reality for corrective maintenance	New Course			

Table 15 Priority courses for Production 4.0

HEI	Programme	Module	Existing / New	Number of selected activities	Important activities	Percentage of important activities
IIT	Indus Eng	Industrial system engineering : planning and scheduling	Extend existing Course	5	PPS 6- 7 – 9, PPS10	100%
		Production and inventory management	Extend existing Course	3	PIM 2-4-6	100%
UIT	Indus Eng	Planification et ordonnancement	Extend existing Course	3	PPS 6- 7	66%
	Indus Eng	Gestion de la production	Extend existing Course	20	PPS 7, PIM 2-6, PPMC11, PPS 10, PIM2-4, PPMC, 8,9, 10	75%
	ERP – ICL	Gestion de production, planification et exécution	Extend existing Course	14	PPS10, PIM4, PIM6	21%
UCAR	IIA	Production, planning, scheduling and control in industry 4.0	New Course			
		Factory 4.0 : Concepts and techniques	New Course			
	IMI	Production, planning, scheduling and control in industry 4.0	New Course			
		Factory 4.0 : Concepts and techniques	New Course			

ECC		S7 - Gestion des opérations	Extend existing Course	31	PPS6,7,9, PIM2, PIM6, PPMC 11	19%
		Production, planning, scheduling and control in industry 4.0	New Course			
		Supply chain 4.0 : Concepts and techniques	New Course			

Table 16 Priority courses for Quality 4.0

HEI	Programme	Module	Existing / New	Number of selected activities	Important activities	Percent age of important activities
IIT	Indus Eng	Internal Control	Extend existing Course	4	QPmC7 to 9	50%
		Statistical Quality Control	Extend existing Course	7	QInC1 – QInC7	100%
UIT	Indus Eng	Démarche qualité et projets industriel tuteurés	Extend existing Course	21	QInC1 to 7 QPmC2, QPmC3, QPmC7 to QPmC9	57%
	ERP – ICL	Management de la qualité et lean SIX sigma	Extend existing Course	20	QInC1 to 7 QPmC2, QPmC3, QPmC7 to 9	60%
		Real time quality control	New Course			
UC AR	IIA	Quality management and Industrial Performances	Extend existing Course	1		0%
		Quality tools and approaches	Extend existing Course	6	QInC1 QPmC2 - QPmC3	50%
	IMI	Management Tools of Quality Control	Extend existing Course	8	QInC1 QPmC2 - QPmC3	37%
	FSEGN	Statistical Quality Control	Extend existing Course	6	QInC1,QInC2 ,QInC4	50%
ECC		S9 - Lean Six Sigma	New course			
		Product driven-control	New course			

8. Definition of new common courses to be developed

It was defined that by the end of this project six new courses will be developed and added to current programs in PC HEI. In order to find common links between the different programs and facilitate the implementation of new courses, the definitions of these new courses should be based on the priority courses and their assigned activities. The development of these new courses will be performed in work package 2.

The list of new courses that are adopted at the end of T1.4 are as following. For the maintenance :

- Course 1 : Advanced Maintenance Strategies
- Course 2 : Integrated Maintenance Planning

For the production:

- Production, planning, scheduling and control in industry 4.0
- Factory 4.0 : Concepts, techniques, and applications

And for the quality:

- Advanced PSS Quality Design
- QC analytics for Zero defect manufacturing

Table 17 illustrates the assignment of most selected activities in the different programs to the six new courses. From this table, we can notice that the important activities are selected more than the other activities which help later to develop the detailed contents of new courses and implement them (in work package 2).

Table 17 Common Courses and activities

Course		Important activities	Other Activities	Percentage of common activities
Advanced Maintenance Strategies	Corrective		MC6	50%
	Preventive	MPrev7	MPrev11	
	Predictive	MPred3, MPred10, MPred7, MPred4, MPred5	MPred1, Sensor Networks design	
Integrated Maintenance Planning	Corrective		MC5	83%
	Preventive	MPrev6, MPrev8, MPrev9, MPrev10		
	Predictive	MPred9		
Production, planning, scheduling and control in industry 4.0	Planning & Scheduling	PPS6, PPS7	PPS4, PPS11, PPS8	62%
	Inventory Management	PIM2, PIM4, PIM6		
	Production monitoring and control		PPMC12	

Factory 4.0 : Concepts, techniques, and applications	Planning & Scheduling	PPS9		40%
	Inventory Management	PIM9		
	Production monitoring and control	PPMC9, PPMC11	PPMC1, PPMC4, PPMC5, PPMC7, PPMC13, PPMC17	
Advanced PSS Quality Design	In-process product quality control	QInC1, QInC2, QInC4, QInC6	QQM2	83%
	Post- manufacturing quality control	QPmC8		
	Quality management			
QC analytics for Zero defect manufacturi ng	In-process product quality control			50%
	Post- manufacturing quality control	QPmC7	Prescriptive and adaptive decision	
	Quality management	QQM6, QQM8	Quality impact assessment and implementation Integrated process improvement	