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

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

D2.4 Pilot 3: Quality Engineering

Deliverable Identifier	**D2.4**
Deliverable Date	**M40 – 15/05/2024**
Deliverable Version	**V 1.4 - 2024**
Deliverable Leader	**BIBA**
Deliverable participants	**All**
Dissemination Level	**Confidential**

Document Control Page

Title	Pilot 3: Quality Engineering
Version	V1.4 - 2024
Deliverable number	D2.4
Work-Package	WP2
Status	☐ Draft ☐ Under Review ☐ Under Update ☐ Accepted by the coordinator ☒ Submitted to the commission
Authors	Zied Ghrairi (BIBA)
Contributors	All partners
Peer Reviewers 1:	Andre Rocha (UNL)
Assigned Date	18/12/2023
Received Date	20/12/2023
Peer Reviewers 2:	Abdelmajid Elouadi (UIT)
Assigned Date	20/12/2023
Received Date	23/12/2023
Date of Delivery	15/05/2024
Dissemination level	☒ Public ☐ Confidential, only for ENHANCE Consortium (including EC) ☐ EU-Restricted

Version History

Version	Date	Description	Edited by
1.0	05.10.2023	Initial Version	BIBA
1.1	31.11.2023	Draft for Consortium sharing	BIBA
1.2	20.12.2023	Final Draft with integration of comments from reviewers	BIBA
1.3	22.12.2023	Final Version	BIBA
1.4	14/06/2024	Submitted to the commission	Nejib Moalla

Executive summary

This deliverable reflects the effort performed by the ENHANCE partners mainly in WP2 (development) for the creation of the learning materials for the topic Quality 4.0. The deliverable reports on the list of all the courses and related activities recommended by all the stakeholders (academic partners, industrial partners). For the topic Quality 4.0, 14 activities have been developed. The partners have adopted an iterative development process based on refining the first version of each activity through subsequent cycles.

Table of Contents

Table of Figures

Table of Tables

1. Introduction

This document is developed as part of the ENHANCE project in the pilot 3 of Quality engineering. The content describes all developed courses and related activities for the topic Quality 4.0, providing a comprehensive overview of the curriculum designed to enhance quality management in the era of Industry 4.0. It includes detailed course descriptions, learning materials, and the integration of advanced technologies such as data analytics and IoT in quality processes. Additionally, the document outlines practical activities and case studies that enable participants to apply theoretical knowledge in real-world scenarios in Quality engineering.

1.1. Purpose of the document

This document aims to describe all the courses and related activities for the topic Quality 4.0. The following figure depicts the list of all the activities. More information about the activities will be given in the next chapter.

Table 1: List of activities for the topic Quality 4.0

Quality 4.0	**Course 5** Advanced PSS Quality Design	Act 5.1: Integrated Systems Thinking: Introduction to Model-Based Systems Engineering
		Act 5.2: Non-Conformities RCA and Quality gates design
		Act 5.3: QC model design
		Act 5.4: Design for X applied for Quality
		Act 5.5: IoT and BPM for Integrated VSM
	Course 6 QC analytics for Zero defect manufacturing	Act 6.1: Integrated process improvement
		Act 6.2: Quality Process maturity self-assessment and lifecycle management
		Act 6.3: Inspection Methods, sampling, Inspection Plan
		Act 6.4: Prescriptive and adaptive decision for Quality Control
		Act 6.5: Quality Planning, Control and Management functions
	Use Cases	Act U.3.1: Sensor's sensitivity analysis and selection
		Act U.3.2: Non-Conformities RCA and Quality gates design
		Act U.3.3 IoT and BPM for Integrated VSM
		Act U.3.4 Process maturity self-assessment and lifecycle management
		Act U.3.5 Prescriptive and adaptive decision for Quality Control

1.2. Reference documents

D1.1, D2.1 and D1.5

1.3. Applicability

This document will be used by interested (from EU, Erasmus PC, etc,) partners to have an overview about all the developed activities and the related details on the LeL Platform. The document is public

1.4. Definitions

N/A

1.5. Structure of the document

This document is organized in 5 sections:

- Section 1: Introduction
- Section 2: Enhance project overview
- Section 3: List of activities developed for course 1 titled Advanced Quality strategies
- Section 4: List of activities developed for course 2 titled QC analytics for Zero defect manufacturing
- Section 5: List of activities developed as use cases

1.6. List of acronyms

BPM	(Business Process Management
CMMI	Capability Maturity Model Integration
IoT	Internet of Things
QC	Quality Control
PSS	Product Service System
RCA	Root Cause Analysis
VSM	Value Stream Mapping

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/. Figure 1 gives an overview of the ENHANCE project organization.

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 presents the overall ENHANCE project organization.

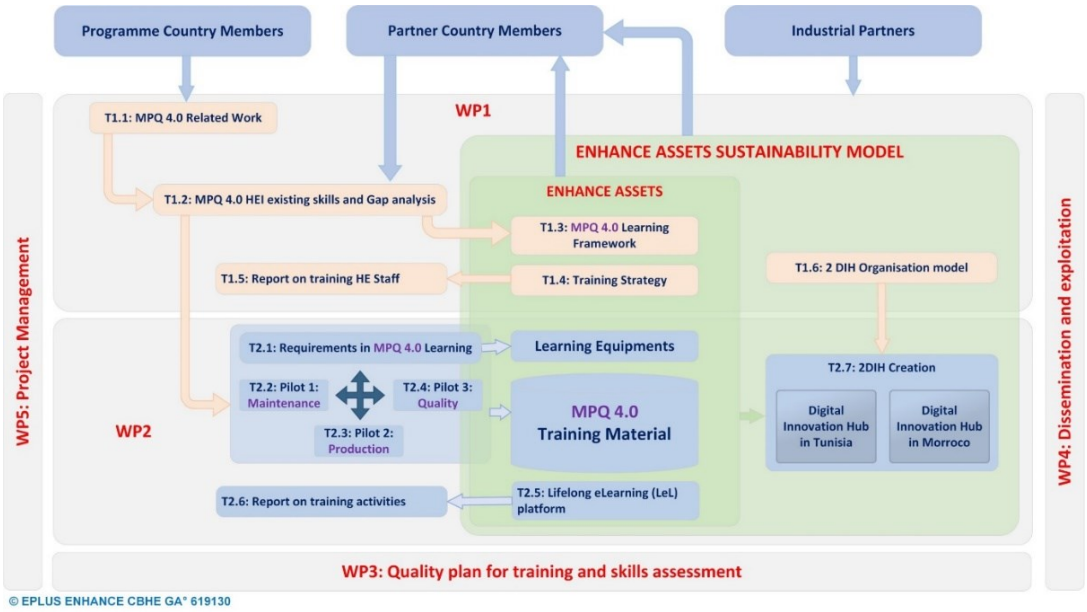

Figure 1: ENHANCE project organization.

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 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.

3. Course 1: Advanced PSS Quality Design

3.1. Course objectives

This course on Advanced PSS Quality Design aims to equip participants with a comprehensive understanding about Model-based system engineering, Non-Conformities RCA and Quality gates design, Quality control model design, Design for X applied for Quality, IoT and BPM for Integrated VSM.

3.2. Presentation of the list of activities

3.2.1. Act 5.1 Integrated systems thinking: Introduction to Model-Based Systems Engineering

- Objectives: Introduction to Model-Based Systems Engineering, Requirements engineering and the use of ARCADIA, CAPELLA, UML and SYSML
- Link on the LeL Platform: https://lel.eplus-enhance.eu/course/view.php?id=30

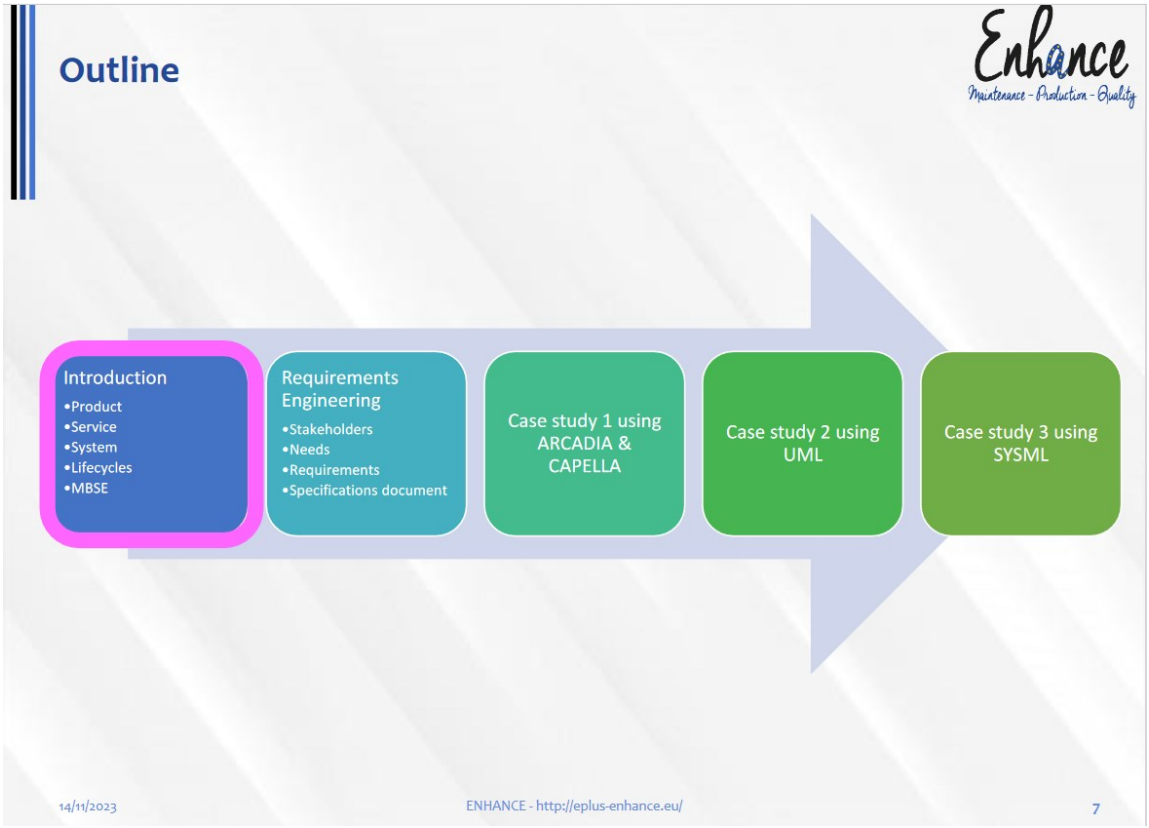

Figure 2: Act 5.1 Integrated systems thinking-Introduction to Model-Based Systems Engineering – content example

Enhance	**Learning Activity Syllabus**						Co-funded by the Erasmus+ Programme of the European Union
ENHANCE Domain	Quality 4.0						
Skill Set	Advanced Quality strategies						
Activity Title	Integrated Systems Thinking : Introduction to Model-Based Systems Engineering						
Activity Acronym	Act_5.1						
Activity Description	Integrated Systems Thinking : Introduction to Model-Based Systems Engineering						
Keywords	Systems modelling	UML	SysML	MBSE			

Teaching task related to I4.0	**Topics**	**Teaching Plan**				**Learning Path**		
	Hard Skill	**Delivery Method (gamification, case study, simulation...)**	**Teaching Material**	**Duration (Hrs)**	**Soft Skill**	**Assesment**	**If FAIL goes to**	**If PASS goes to**
Task 1	Introduction Product Service System Lifecycles MBSE	.Presentation .Infographic communication	ppt slides	4	.Problem Solving .Critical thinking .Team working	Quizz	Task 1 (repeat until done)	Task 2
Task 2	Requirements Engineering Stakeholders Needs Requirements Specifications document	.Presentation .Infographic communication	ppt slides	4	.Problem Solving .Critical thinking .Team working	Quizz	Task 2 (repeat until done)	Task 3
Task 3	Case study 1 using ARCADIA & CAPELLA	.Presentation .Infographic communication	ppt slides	4	.Problem Solving .Critical thinking .Team working	Quizz	Task 3 (repeat until done)	Task 4
Task 4	Case study 2 using UML	.Presentation .Infographic communication	ppt slides	4	.Problem Solving .Critical thinking .Team working	Quizz	Task 4 (repeat until done)	Task 5
Task 5	Case study 3 using SYSML	.Presentation .Infographic communication	ppt slides	4	.Problem Solving .Critical thinking .Team working	Quizz	Task 5 (repeat until done)	Done

Meta Skills							
Module Outcomes	Participants will be able to conduct an Integrated Systems Thinking process using Model-Based Systems Engineering						
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Project report, Project presentation, Assessment of teamwork						
Teaching Material							
Equipment							
Multimedia							
Content URL							
Class requirements *(equipement that participants should bring)*	Laptop/Desktop						
Prerequisites *(previous modules that student should attend)*							
Total duration *(Hrs)*	20						

3.2.2. Act 5.2 Non-Conformities RCA and Quality gates design

- Objectives: Introduce the main concepts related to defect defection, root cause analysis, and quality gates design
- Link on the LeL Platform: https://lel.eplus-enhance.eu/course/view.php?id=34

(access credentials are available for EC reviewers)

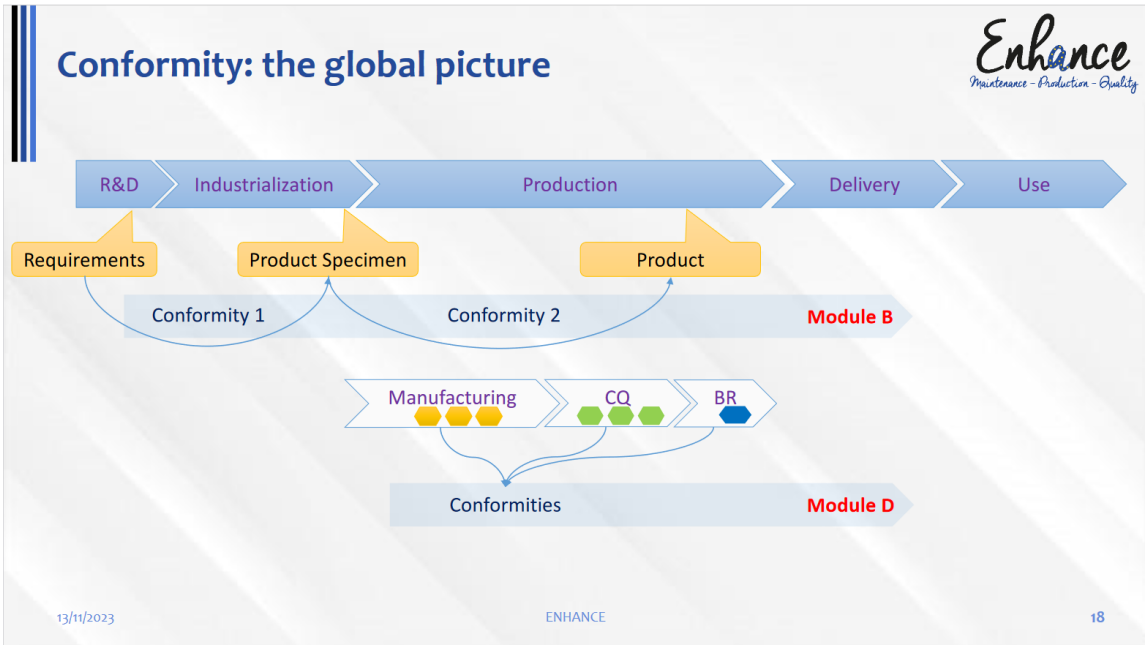

Figure 3: Act 5.2 Non-Conformities RCA and Quality gates design – content example

Enhance	**Learning Activity Syllabus**						Co-funded by the Erasmus+ Programme of the European Union
ENHANCE Domain	Quality						
Skill Set	Advanced PSS Quality Design						
Activity Title	Non-Conformities RCA and Quality gates design						
Activity Acronym	Act_5.2						
Activity Description	Introduce the main concepts related to defect defection, root cause analysis, and quality gates design						
Keywords	Defect	Non-Conformity	RCA	Quality Gate			

Teaching task related to I4.0	**Topics**	**Teaching Plan**				**Learning Path**		
	Hard Skill	**Delivery Method (gamification, case study, simulation...)**	**Teaching Material**	**Duration (Hrs)**	**Soft Skill**	**Assesment**	**If FAIL goes to**	**If PASS goes to**
Task1: NonConformity Analysis (NCA)	- Conformity Assessment - Conformity modules - Encoding defective causes	- Presentation	- PPTX Slides	4h	- Problem Solving - Critical thinking	Quizz_1	Task 1	task 2
Task2: Root-Cause-Analysis (RCA)	- Approaches to Root Cause Analysis - Root-Cause-Analysis guide	- Presentation	- PPTX Slides	2h	- Problem Solving - Critical thinking	Quizz_2	Task 2	Task 3
Task3: Quality Gates (QG)	- Quality Gate (QG) - Virtual Quality Gate (QG)	- Presentation	- PPTX Slides	2h	- Problem Solving - Critical thinking	Quizz_3	Task 3	

Meta Skills							
Module Outcomes	Participants will be able to understand how to identify, encode, analyse and resolve detected defect	Participants will be able to design quality gate					
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Quizzes to be proposed at the end of each task						
Teaching Material							
Equipment							
Multimedia							
Content URL							
Class requirements *(equipement that participants should bring)*	Computers						
Prerequisites *(previous modules that student should attend)*	Act 4.4 KPI, Dashboarding and data visualisation						
Total duration *(Hrs)*	8h						

3.2.3. Act 5.3 QC model design

- Objectives: This activity figure out the link between integrated process development and product quality
- Link on the LeL Platform: https://lel.eplus-enhance.eu/course/view.php?id=36

(access credentials are available for EC reviewers)

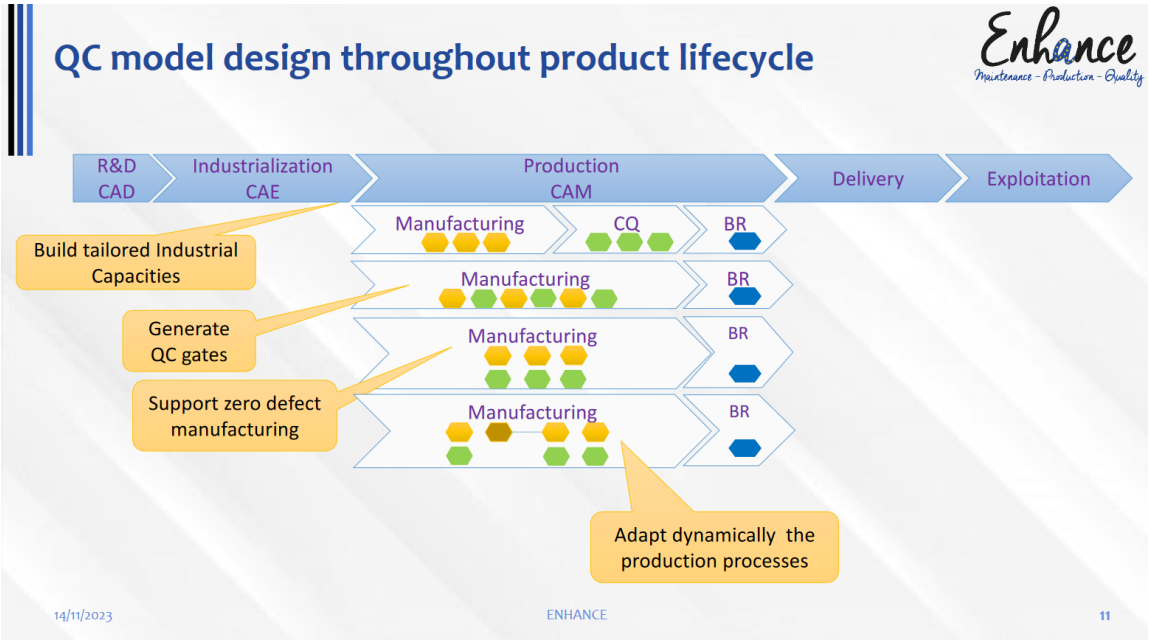

Figure 4: Act 5.3 QC model design – content example

Enhance	**Learning Activity Syllabus**						Co-funded by the Erasmus+ Programme of the European Union
ENHANCE Domain	Quality						
Skill Set	Advanced PSS Quality Design						
Activity Title	QC model design						
Activity Acronym	Act_5.3						
Activity Description	This acitivity figure out the link between integrated process development and product quality						
Keywords	Integrated product design	QC model design					

Teaching task related to I4.0	**Topics**	**Teaching Plan**				**Learning Path**		
	Hard Skill	**Delivery Method (gamification, case study, simulation...)**	**Teaching Material**	**Duration (Hrs)**	**Soft Skill**	**Assesment**	**If FAIL goes to**	**If PASS goes to**
Task 1: Integrated product design & product quality	- Integrated product design - Integrated product development	- Presentation	- PPTX Slides	8h	- Problem Solving - Critical thinking	Quizz_1	Task 1	task 2
Task 2: QC models design throughout product lifecycle	- CAD-CAM QC model design - CAM and product quality data - Product exploitation & product quality data	- Presentation	- PPTX Slides	6h	- Problem Solving - Critical thinking	Quizz_2	Task 2	

Meta Skills						
Module Outcomes	Participants will be able to understand how to use product design and development data for product quality					
Target Group *(students, workers...)*	Master students	SME personnels				
Assessment Method	Quizzes to be proposed at the end of each task					
Teaching Material						
Equipment						
Multimedia						
Content URL						
Class requirements *(equipement that participants should bring)*	Computer					
Prerequisites *(previous modules that student should attend)*	Act 5.2 Non-Conformities RCA and Quality gates design					
Total duration *(Hrs)*	14h					

3.2.4. Act 5.4 Design for X applied for Quality

- Objectives: This activity presents the basic concept and principles of Design for X, their practices, and tools. Particularly, among the several approaches of the design for X, the focus is on the design for X for Quality in the context of Industry 4.0, taking into consideration different aspects and context such as the resilience, agility, maintainability, sustainability, etc.
- Link on the LeL Platform: https://lel.eplus-enhance.eu/course/view.php?id=12

(access credentials are available for EC reviewers)

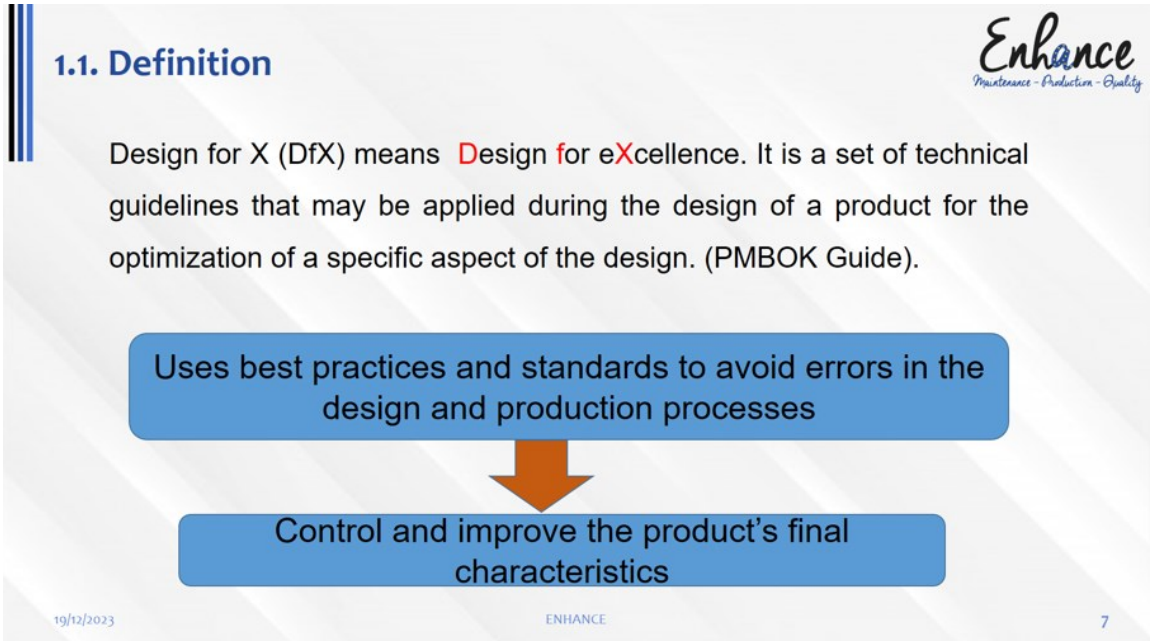

Figure 5: Act 5.4 Design for X applied for Quality – content example

Learning Activity Syllabus

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

ENHANCE Domain	Quality						
Skill Set	Advanced PSS Quality Design						
Activity Title	Design for X applied for Quality						
Activity Acronym	Act_5.4						
Activity Description	This activity presents the basic concept and principles of Design for X , their practices, and tools. Particularly, among the several approaches of the design for X, this course is focused on the design for X for Quality in the context of Industry 4.0, taking into consideration different aspects and context such as the resilience, agility, maintainability, sustainability, etc.						
Keywords	Design	X					

Teaching task related to I4.0	**Topics**		**Teaching Plan**				**Learning Path**		
	Hard Skill		**Delivery Method (gamification, case study, simulation...)**		**Teaching Material**	**Duration (Hrs)**	**Soft Skill**	**Assesment**	**If FAIL goes to**	**If PASS goes to**
Basic concepts of design for X	Presentation	Case study	PPT file	2 hour	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	Question 1	Task 1	task 1 (SND)	task 1 (SND)	task 2 (SND)
Design for Quality	Simulation	Case study	PPT file	2 hour	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	Question 2	Task 1	task 2 (SND)		

Meta Skills	Finding and maintaining purpose						
Module Outcomes	Participants will be able to identify the optimal approach of design for Quality in industry 4.0.		Participants will be able to identify the key elements of a design for X for Quality.				
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Project report, Project presentation, Assessment rubric for teamwork						
Teaching Material							
Equipment	Computer		Cloud server				
Multimedia	Lecture notes						
Content URL	Video URL						
Class requirements *(equipement that participants should bring)*	Computer						
Prerequisites *(previous modules that student should attend)*	Data acquisition and analysis						
Total duration *(Hrs)*	4						

3.2.5. Act 5.5 IoT and BPM for Integrated VSM

- Objectives: This activity presents the basic concept and principles of lean management 4.0 and VSM 4.0, their practices, and tools. It is based on considering that Value Stream Mapping in industry 4.0 is a highly interactive, visible process, which illustrates the steps required to deliver a product or service. The content is thus designed to help businesses to identify and remove/reduce waste in their daily operations based on sensors, IT and IoT.
- Link on the LeL Platform: https://lel.eplus-enhance.eu/course/view.php?id=6

(access credentials are available for EC reviewers)

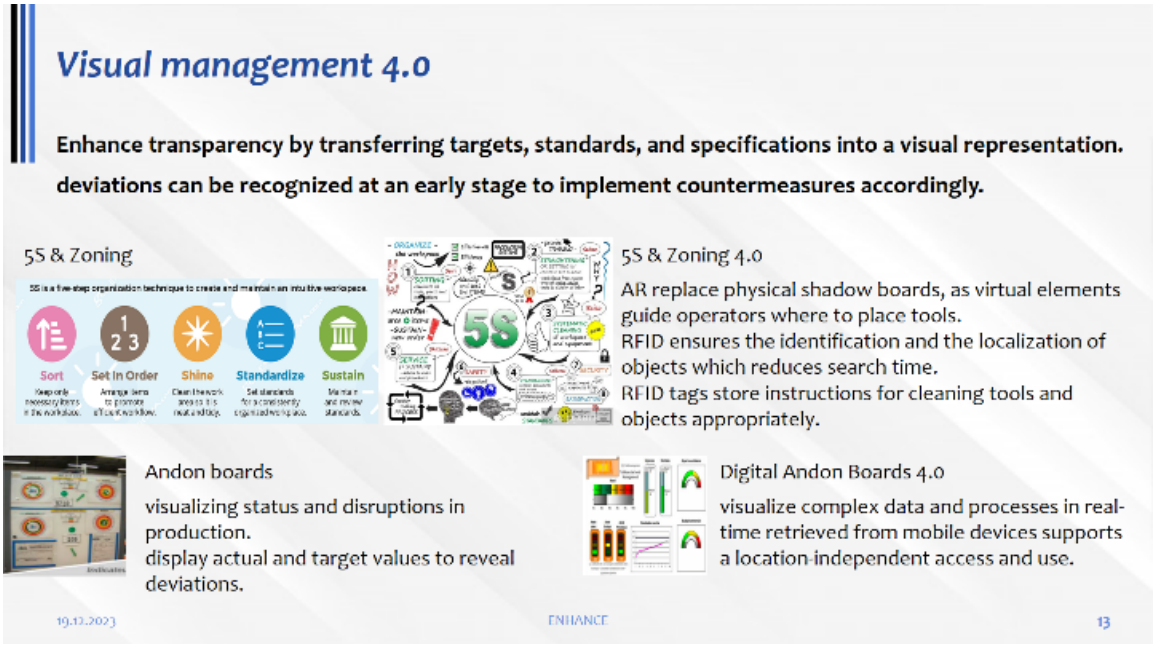

Figure 6: Act 5.5 IoT and BPM for Integrated VSM – content example

Enhance	**Learning Activity Syllabus**						Co-funded by the Erasmus+ Programme of the European Union
ENHANCE Domain	Quality						
Skill Set	QC analytics for Zero defect manufacturing	Integrated process improvement					
Activity Title	QQM2 Business process management -VSM						
Activity Acronym	Act_5.5						
Activity Description	This activity presents the basic concept and principles of lean management 4.0 and VSM 4.0, their practices, and tools. It is based on considering that Value Stream Mapping in industry 4.0 is a highly interactive, visible process which illustrates the steps required to deliver a product or service. The content is thus designed to help businesses to identify and remove/reduce waste in their daily operations based on sensors, IT and IOT.						
Keywords	Lean; VSM 4.0						

Teaching task related to I4.0	**Topics**	**Teaching Plan**				**Learning Path**		
	Hard Skill	**Delivery Method (gamification, case study, simulation...)**		**Teaching Material**	**Duration (Hrs)**	**Soft Skill**	**Assesment**	**If FAIL goes to**	**If PASS goes to**
Lean management 4.0	Principals of lean management 4.0 Tools of lean management 4.0	Simulation	Case study	PPT file	1 hour	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	Question 1	Task 1	task 2 (SND)
Framework of automated VSM-VSM 4.0	Principle of VSM / VSM 4.0 elements and drawing methods/ advantages of VSM 4.0	Simulation	Case study	PPT file	2 hour	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	Question 1	Task 1	task 2 (SND)
The exploitation of VSM to create new business processes : An example	Interpret and understand the utility and the added value of VSM 4.0 compared to conventionnal VSM.	Simulation	Case study	PPT file	1 hour	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	Question 1	Task 1	task 2 (SND)

Meta Skills	Finding and maintaining purpose						
Module Outcomes	Participants will be able to draw a VSM 4.0		Participants will be able to use necessery new technologies and techniques to transform a conventional VSM into a VSM 4.0				
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Project report, Project presentation, Assessment rubric for teamwork						
Teaching Material							
Equipment	VSM Software						
Multimedia	Lecture notes						
Content URL	Video URL						
Class requirements *(equipement that participants should bring)*	Computer						
Prerequisites *(previous modules that student should attend)*							
Total duration *(Hrs)*	4						

4. Course 2: QC analytics for Zero defect manufacturing

4.1. Course objectives

This course on QC analytics for Zero defect manufacturing aims to equip participants with a comprehensive understanding about: Integrated process improvement, Quality Process maturity self-assessment and lifecycle management, Inspection Methods, sampling, Inspection Plan, Prescriptive and adaptive decision for Quality Control, Quality Planning, Control and Management functions, Sensors sensitivity analysis and selection, Non-Conformities RCA and Quality gates design, IoT and BPM for Integrated VSM, Prescriptive and adaptive decision for Quality Control.

4.2. Presentation of the list of activities

4.2.1. Act 6.1 Integrated process improvement

- Objectives: This activity presents the Integrated process improvement concept and tools. It provides details about the CMMI for process improvement, Process Mapping and Process architecture and improvements.
- Link on the LeL Platform: https://lel.eplus-enhance.eu/course/view.php?id=16

(access credentials are available for EC reviewers)

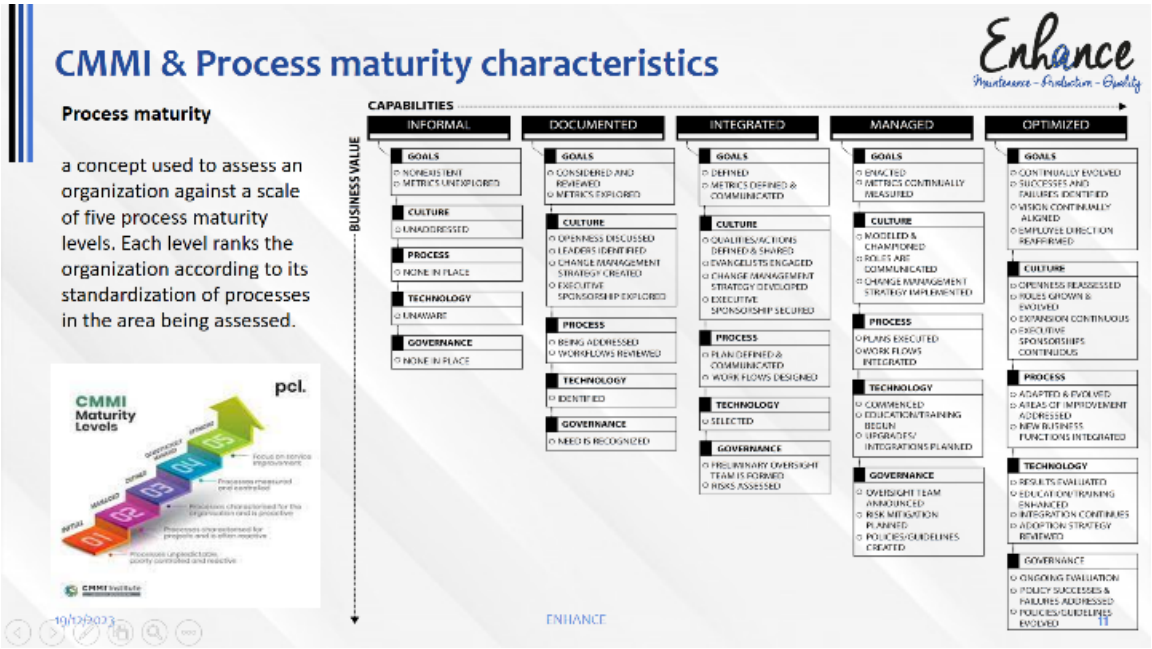

Figure 7: Act 6.1 Integrated process improvement – content example

Learning Activity Syllabus

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

ENHANCE Domain	Quality						
Skill Set	QC analytics for Zero defect manufacturing						
Activity Title	Act 6.1: Integrated process improvement						
Activity Acronym	Act_6.1						
Activity Description	This task presents the Integrated process improvement concept and tools. It provides details about the CMMI for process improvement, Process Mapping and Process architecture and improvements.						
Keywords	Integrated process	Architecture	Improvement				

Teaching task related to I4.0	**Topics**	**Teaching Plan**				**Learning Path**		
	Hard Skill	**Delivery Method (gamification, case study, simulation...)**		**Teaching Material**	**Duration (Hrs)**	**Soft Skill**	**Assesment**	**If FAIL goes to**	**If PASS goes to**
CMMI for process improvement	Process approach Key concepts ; Process Standardization and CMMI & Process maturity characteristics.	Presentation	Case study	PPT file	1 hour	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	Question 1	Task 1	task 2 (SND)
Process Mapping	Process modeling and mapping	Presentation	Case study	PPT file	1 hour	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	Question 2	Task 2	task 3 (SND)
Process architecture and improvements	Process architecture hierarchy and Managing process improvementsand	Presentation	Case study	PPT file	2 hour	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	Question 3	Task 3	

Meta Skills							
Module Outcomes	Participants will be able to make QC analytics for Zero defect manufacturing		Participants will be able to do a process modeling and mapping				
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Project report, Project presentation, Assessment rubric for teamwork						
Teaching Material							
Equipment	Drawing/UML tool						
Multimedia	Lecture notes						
Content URL	NA						
Class requirements *(equipement that participants should bring)*	Computer						
Prerequisites *(previous modules that student should attend)*	NA						
Total duration *(Hrs)*	4						

4.2.2. Act 6.2 Quality Process maturity self-assessment and lifecycle management

- Objectives: The activity addresses following questions: Q1: To what extent can one identify differences in the process approach applicable to economic and non-economic organizations? Q2: What is the importance of accounting for said differences relative to the efficiency and effectiveness of process results?
- Link on the LeL Platform: https://lel.eplus-enhance.eu/course/view.php?id=44

(access credentials are available for EC reviewers)

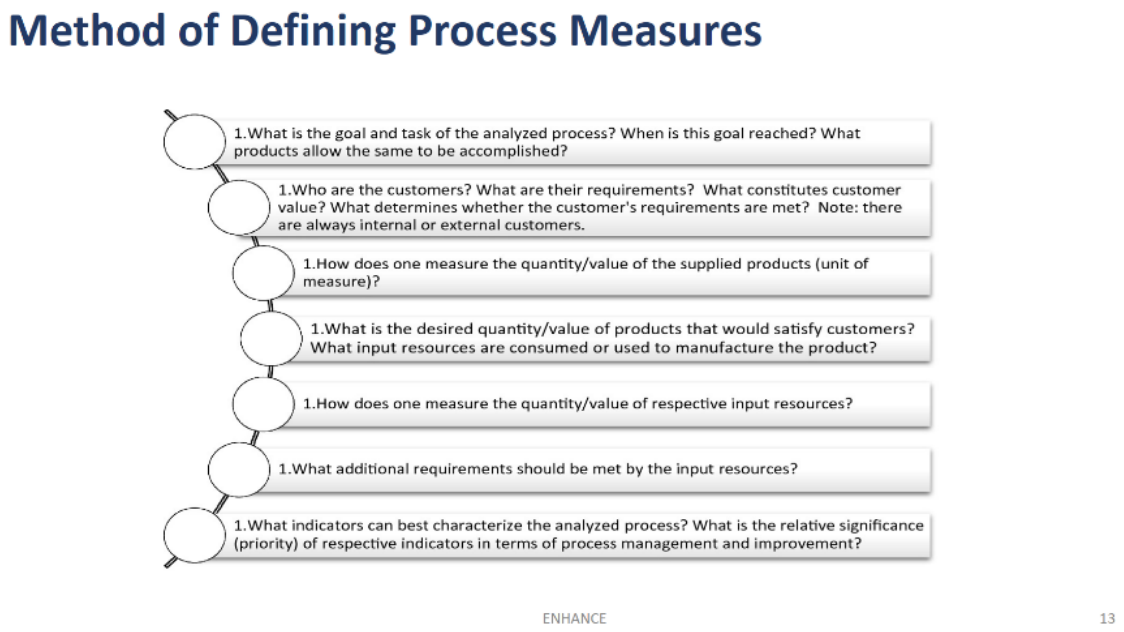

Figure 8: Act 6.2 Quality Process maturity self-assessment and lifecycle management – content example

Enhance	**Learning Activity Syllabus**						Co-funded by the Erasmus+ Programme of the European Union
ENHANCE Domain	Quality						
Skill Set	QC analytics for Zero defect manufacturing						
Activity Title	Act 6.2:Quality Process Maturite self Assesement and Life Cycle Management						
Activity Acronym	ACT_6.2						
Activity Description	Identifying differences in the process approach applicable to economic and non-economic organizations and showing the importance of accounting for said differences relative to the efficiency and effectiveness of process results.						
Keywords	PROCESS MANAGEMENT	MATURITY MODEL	PROCESS LIFE CYCLE	PROCESS MODELING	PROCESS IMPLEMENTATION	PROCESS VERIFICATION	

Teaching task related to I4.0	**Topics**	**Teaching Plan**				**Learning Path**		
	Hard Skill	**Delivery Method (gamification, case study, simulation...)**		**Teaching Material**	**Duration (Hrs)**	**Soft Skill**	**Assesment**	**If FAIL goes to**	**If PASS goes to**
TASK 1 : PROCESS MANAGEMENT	to be able to define Classifications of Organizational Processes	case study	simulation BPMN bizagi	logiciel bpmn bizagi modeler	1 hour	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	Question 1	Task 1	task 2 (SND)
TASK 2 : PROCESS LIFE CYCLE	to be able to Overview of Lifecycle	case study	simulation BPMN bizagi	logiciel bpmn bizagi modeler	1 hour	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	Question 1	Task 1	task 2 (SND)
TASK 3: PROCESS MODELING	to be able to Project Redefinition and Redesign	case study	simulation BPMN bizagi	logiciel bpmn bizagi modeler	1 hour	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	Question 1	Task 1	task 2 (SND)
TASK 4 : PROCESS IMPLEMENTATION	to be able : Implementation and Implementation Models	case study	simulation BPMN bizagi	logiciel bpmn bizagi modeler	1 hour				
TASK 5: PROCESS VERIFICATION	to be able to:enumerate Tools and Methods Facilitating Process Verification	case study	simulation BPMN bizagi	logiciel bpmn bizagi modeler	1 hour				
TASK 6: Models of Process Maturity in Organizations	to be able to : eneumerate maturity model and various tools and practices	case study	simulation BPMN bizagi	logiciel bpmn bizagi modeler	1 hour				

Meta Skills	To be able to e identify differences in the process and the importance of accounting for said differences relative to the efficiency and effectiveness of process results approach applicable to organizations					
Module Outcomes	Participants will be able Identifier et analyser les critères de mesures de l'organisation,	Participants will be able to Devoloper un outil associé à ces critères de mesure.		Participants will be able to Présenter les résultats sous forme graphique.		
Target Group *(students, workers...)*	Master students	SME personnels				
Assessment Method	Project report, Project presentation, Assessment rubric for teamwork					
Teaching Material						
Equipment	laptop					
Multimedia	video					
Content URL	https://www.sydle.com/bizagi-alternative/?utm_campaign=sydle-bpm-en&utm_source=google&utm_medium=cpc&utm_campaignid=131708751&utm_content=6529364031&utm_device=c&utm_matchtype=p&utm_adposition=&utm_term=bizagi&gad_source=1&gclid=Cj0KCQiAm4WsBhCiARIsAEJIEzVXmaqLULPEA1IL9AfmjR9XIqXAUaRdgvTHLnF8ivCOtYi-ka-fr90aAkhREALw_wcB					
Class requirements *(equipement that participants should bring)*	laptop					
Prerequisites *(previous modules that student should attend)*	BPMN					
Total duration *(Hrs)*	6h					

4.2.3. Act 6.3 Inspection Methods sampling Inspection Plan

- Objectives: The activity of Inspection Methods, Sampling, and Inspection Plan involves developing procedures for inspections, determining sampling techniques, and creating plans to ensure quality control and compliance with standards.
- Link on the LeL Platform: https://lel.eplus-enhance.eu/course/view.php?id=40

(access credentials are available for EC reviewers)

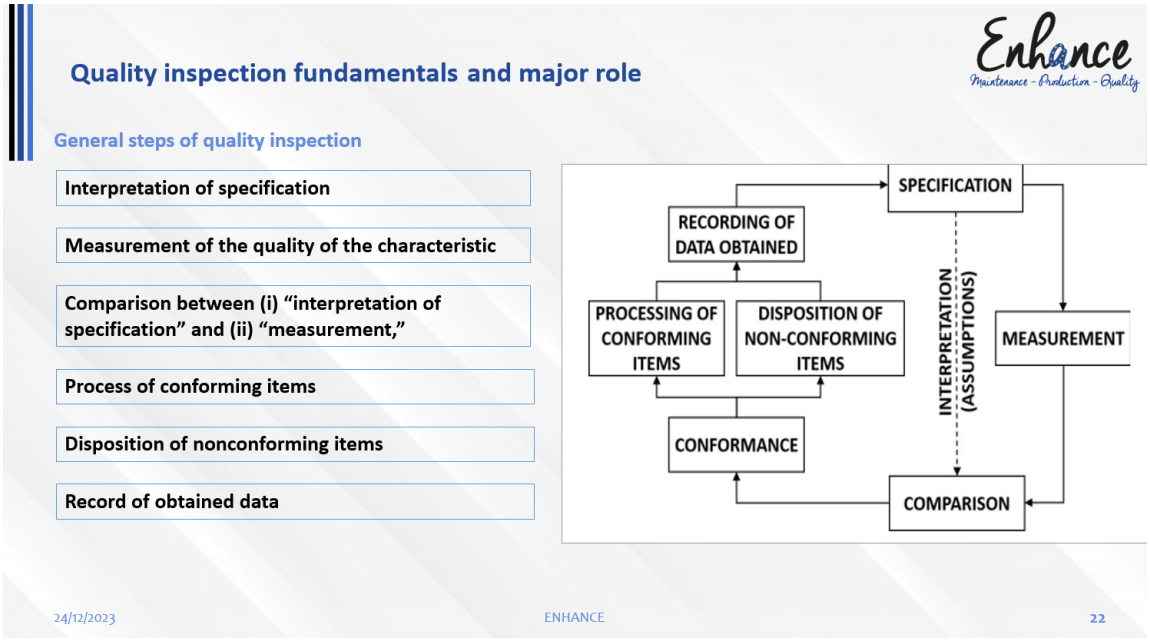

Figure 9: Act 6.3 Inspection Methods sampling Inspection Plan – content example

Enhance Maintenance - Production - Quality	**Learning Activity Syllabus**						Co-funded by the Erasmus+ Programme of the European Union			
ENHANCE Domain	Quality4.0									
Skill Set	QC analytics for Zero defect manufacturing									
Activity Title	Act 6.3: Inspection Methods, sampling, Inspection Plan									
Activity Acronym	Act_6.3									
Activity Description	The activity of Inspection Methods, Sampling, and Inspection Plan involves developing procedures for inspections, determining sampling techniques, and creating plans to ensure quality control and compliance with standards.									
Keywords	Inspection Methods	control	quality control							
Teaching task related to I4.0	**Topics**		**Teaching Plan**					**Learning Path**		
	Hard Skill		**Delivery Method (gamification, case study, simulation...)**		**Teaching Material**	**Duration (Hrs)**	**Soft Skill**	**Assesment**	**If FAIL goes to**	**If PASS goes to**
Task 1 : Quality and Total Quality Management	Quality assurance, Process improvement, Data analysis, Continuous improvement, Auditing, Lean methodology, Six Sigma, Root cause analysis, Statistical analysis, Quality control.		presentation		ppt file	2	Attention to detail Analytical thinking Communication skills Problem-solving abilities	MCQ	Iterate Task 1	Task2
Task 2 : Sampling for quality control	Statistical sampling techniques, data analysis, quality standards, software proficiency.		presentation		ppt file	3	Attention to detail Analytical thinking Communication skills Problem-solving abilities	MCQ	Iterate Task 2	Task3
Task3 : Quality control in industry 4.0 : tools and technologies	Utilizing advanced quality control tools and technologies in Industry 4.0, including automated inspection systems, data analytics, AI, and IoT-enabled devices.		presentation		ppt file	3	Attention to detail Analytical thinking Communication skills Problem-solving abilities	MCQ	Iterate Task 3	Task4
Task 4 : Multi-Layer quality control framework for industry 4.0	Implementing and managing multi-layer quality control systems in Industry 4.0, including real-time data analysis, machine learning, and integration with smart manufacturing for continuous improvement.		presentation		ppt file	3	Attention to detail Analytical thinking Communication skills Problem-solving abilities	Project for quality control in industry 4.0		
Task 5 : Example of Integration of the quality control process into a 4.0 production system	Quality management, process automation, data analysis, real-time monitoring, IoT integration, statistical process control.		presentation	use case	ppt file	2	Attention to detail Analytical thinking Communication skills Problem-solving abilities			
Meta Skills	To be a Quality Control Inspector To be a Quality Assurance Analyst									
Module Outcomes	Participants will be able to develop effective inspection methods and procedures.		Participants will be able to create comprehensive sampling plans for quality assessment.							
Target Group *(students, workers...)*	Master students	SME personnels								
Assessment Method	quisiz at the end of tasks, project									
Teaching Material										
Equipment	3D scanner									
Multimedia										
Content URL	Video URL									
Class requirements *(equipement that participants should bring)*	Computer									
Prerequisites *(previous modules that student should attend)*	descriptive statistics and probabilities									
Total duration *(Hrs)*	13									

4.2.4. Act 6.4 Prescriptive and adaptive decision for Quality Control

- Objectives: This course is devoted to decision-making process in Quality Control.
- Link on the LeL Platform: https://lel.eplus-enhance.eu/course/view.php?id=25

(access credentials are available for EC reviewers)

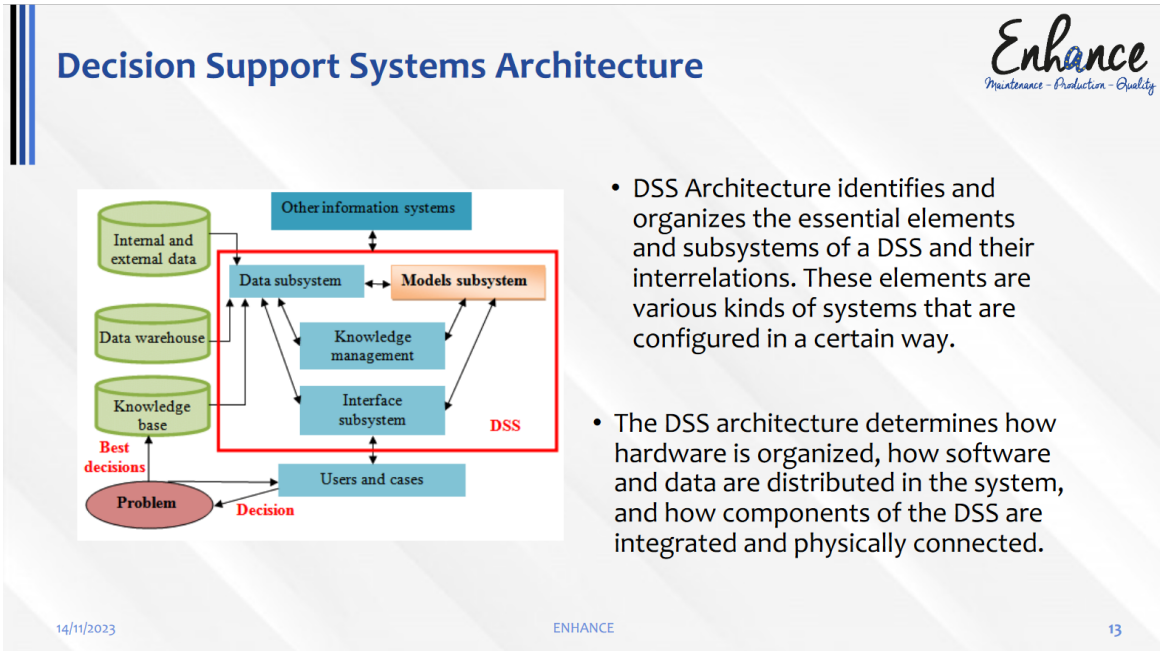

Figure 10: Act 6.4 Prescriptive and adaptive decision for Quality Control – content example

Learning Activity Syllabus

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

ENHANCE Domain	Quality 4.0					
Skill Set	Ability to understand the application of ML-enhanced decision making in Quality domain.					
Activity Title	Prescriptive and adaptive decision for Quality Control					
Activity Acronym	Act_6.4					
Activity Description	This course is devoted to decision making process in Quality Control.					
Keywords	Decision Support Systems	Machine Learning	Business Analytics	Active/Re-active decision making		

Teaching task related to I4.0	**Topics**		**Teaching Plan**					**Learning Path**		
	Hard Skill		**Delivery Method (gamification, case study, simulation...)**		**Teaching Material**	**Duration (Hrs)**	**Soft Skill**	**Assesment**	**If FAIL goes to**	**If PASS goes to**
1. Fundamentals	Understanding of different business anlytics types, Understanding of decision making process		Lecture	Group Discussion	.ppt file	1h	.Critical thinking .Presentation .Infographic communication	Question 1	Task 3 (MDIS)	task 2 (SND)
2. Decision Support Systems	Understanding of types, architectures and characteristics of decision making systems		Lecture	Group Discussion	.ppt file	1h	.Critical thinking .Presentation .Infographic communication			
3. Reactive and Active decision support systems	Clear differentiation between active and re-active decision support systems, introduction of the concept of intelligent decision support systems		Lecture	Group Discussion	.ppt file	1h	.Critical thinking .Presentation .Infographic communication			

Meta Skills							
Module Outcomes	Participants will be able to understand the difference between active and re-active decision making		Participants will be able to understnad the basic decision making process.				
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Project report, Project presentation						
Teaching Material							
Equipment							
Multimedia	Lecture notes						
Content URL							
Class requirements *(equipement that participants should bring)*	Computer						
Prerequisites *(previous modules that student should attend)*	N/A						
Total duration *(Hrs)*	3						

4.2.5. Act 6.5 Quality Planning Control and Management functions

- Objectives: It addresses the concepts related to the reduction in the complexity of product quality planning for the customers and organizations, A means for organizations to easily communicate product quality planning requirements to suppliers.
- Link on the LeL Platform: https://lel.eplus-enhance.eu/course/view.php?id=45

(access credentials are available for EC reviewers)

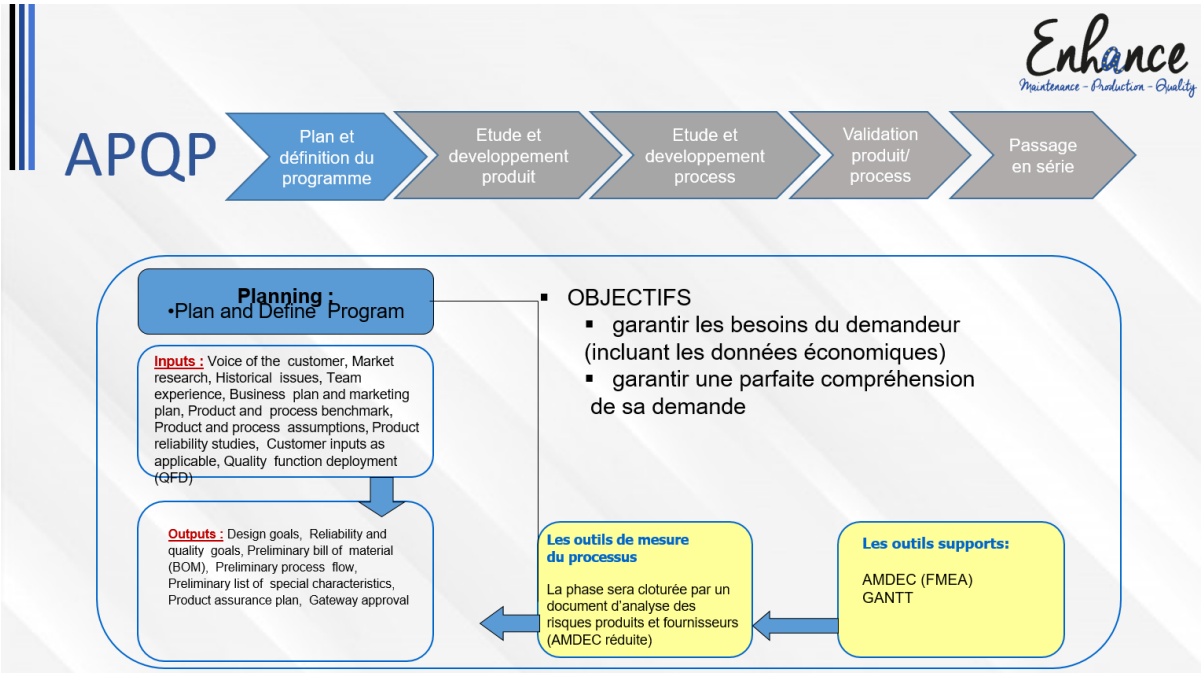

Figure 11: Act 6.5 Quality Planning Control and Management functions – content example

Learning Activity Syllabus

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

ENHANCE Domain	Qualite 4.0
Skill Set	QC Analytics for Zero Defect Manufacturing
Activity Title	Quality Planning, Quality Control, Quality management fonctions – Functions
Activity Acronym	Act_6.5
Activity Description	The activity adresses the concepts the reduction in the complexity of product quality planning for the customers and organizations . A means for organizations to easily communicate product quality planning requirements to suppliers.
Keywords	Quality management fonctions (QMF),Quality Planing (QP) ,Advanced Product Quality Planning (APQP),Advanced Product Quality Planning and Control Plan (APQP&CP)

Teaching task related to I4.0	**Topics**	**Teaching Plan**				**Learning Path**		
	Hard Skils	**Delivery Method (gamification, case study, simulation...)**	**Teaching Material**	**Duration (Hrs)**	**Soft Skill**	**Assesment**	**If FAIL goes to**	**If PASS goes to**
TASK 1: theories and applications for Quality management	to be able to: 1.Define the quality organization function. 2. To discuss the quality management delegation process. 3. To present different quality organizational structures.	.Presentation .Infographic communication	ppt slides white papers	2	.Problem Solving .Critical thinking	Quizz	Task 1 (repeat until done)	
TASK 2:Quality planing	to be able to: 1. To emphasize the importance of planning in the quality management system. 2. To compare and contrast formal and informal planning. 3. To provide a systematic approach to planning.	.Presentation .Infographic communication	ppt slides white papers	2	.Problem Solving .Critical thinking .Team working	Quizz	Task 3 (repeat until done)	
TASK 4: Advanced Product Quality Planning	to be able to: facilitate communication between all persons and activities involved in a program and ensure that all required steps are completed on time, with a high quality-of-event, at acceptable cost and quality levels.	.Presentation .Infographic communication	ppt slides white papers	2	.Problem Solving .Critical thinking .Team working	Quizz	Task 4 (repeat until done)	
TASK 4: Advanced Product Quality Planning	To be able to appliqued Advanced Product Quality Planning (APQP) : 1 -Plan and define 2 -Product design and developpement 3 -Processus design and developpement 4 -Product and Processus validation 5 -Feedback assesement and corective plan	.Presentation .Infographic communication . case study	ppt slides white papers	4	.Problem Solving .Critical thinking .Team working			
Meta Skills	to be able to provide general guidelines for ensuring that Advanced Product Quality Planning is implemented in accordance with the requirements of the customer. It does not give specific instructions on how to arrive at each APQP or Control Plan entry, a task best left to each organization							
Module Outcomes	Participants will be able to to identifie most situations normally occurring either in the early planning, design phase, or process analysis, there will be questions that arise.							
Target Group *(students, workers...)*	Master students / SME personnels							
Assessment Method	Project report, Project presentation, Assessment rubric for teamwork							
Teaching Material								
Equipment								
Multimedia								
Content URL								
Class requirements *(equipement that participants should bring)*								
Prerequisites *(previous modules that student should attend)*	ACT 6.1 / ACT 6.3	ACT6.2 / ACT 5.4						
Total duration *(Hrs)*	12							

5. Use cases

5.1. Course objectives

The objective of the Use Cases for Quality 4.0 is to demonstrate:

- The versatile integration of digital and analogical sensors and related mechanisms for data handling (acquisition, exploration, analysis, etc.).
- The implementation of quality gates concepts for selected industrial processes using QC data.
- The modelling, simulation, execution and optimisation of quality related business processes
- The employment of decision-making processes to improve the quality of manufacturing process.

5.2. Presentation of the list of activities

5.2.1. Act U.3.1 Sensors sensitivity analysis and selection

- Objectives: This task aims at investigating the set of processes requested to make use of digital and analogical sensors. It covers the signal / data acquisition, data exploration, event detection, machine learning algorithms selection and application, etc.
- Link on the LeL Platform: https://lel.eplus-enhance.eu/course/view.php?id=38

(access credentials are available for EC reviewers)

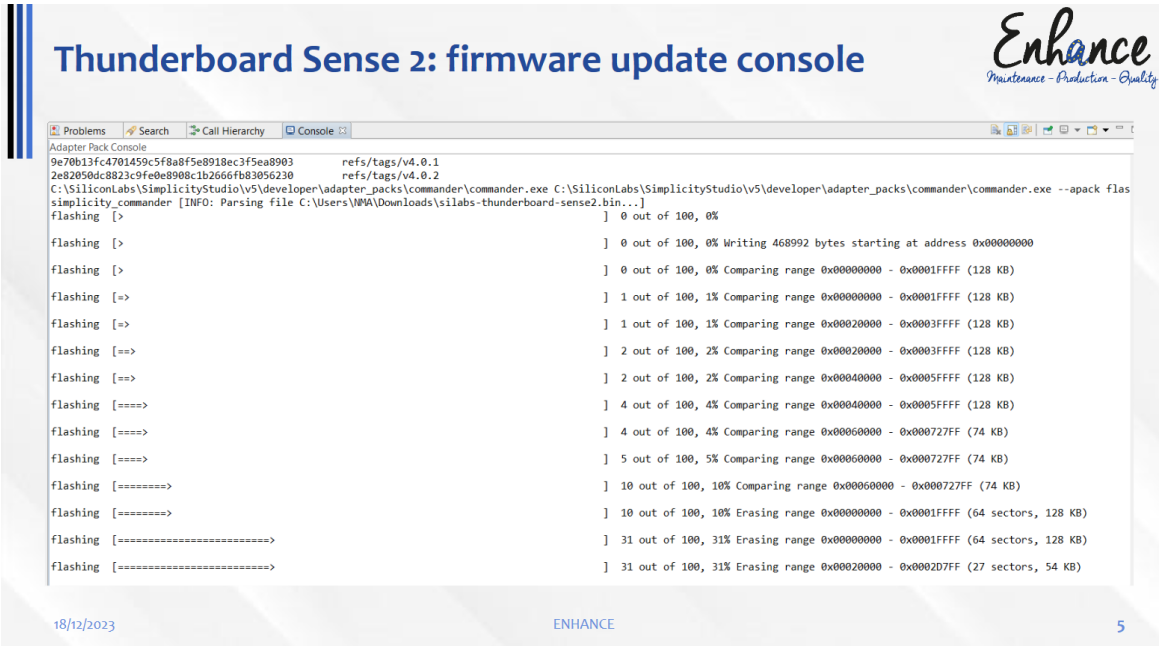

Figure 12: Act U.3.1 Sensors sensitivity analysis and selection – content example

Enhance	**Learning Activity Syllabus**					Co-funded by the Erasmus+ Programme of the European Union	
ENHANCE Domain	Quality						
Skill Set	Quality use cases						
Activity Title	Sensors sensitivity analysis and selection						
Activity Acronym	Act_U3.1						
Activity Description	This task aims at investigating the set of processes requested to make use of digital and anological sensors. It covers the signal / data acquisition, data exploration, event detection, machine learning algorithms selection and application, etc.						
Keywords	Digital sensors	Analogical Sensors	Data Collection	Signal event detection	Machine Learning		

Teaching task related to I4.0	**Topics**	**Teaching Plan**				**Learning Path**		
	Hard Skill	**Delivery Method (gamification, case study, simulation...)**	**Teaching Material**	**Duration (Hrs)**	**Soft Skill**	**Assesment**	**If FAIL goes to**	**If PASS goes to**
Task 1: Digital sensor sensitivity analysis	- Collect digital signals from 6 sensors using SiLabs Thunderboard Sense 2: - Use edge Impulse technologies for sensing data exploitation - Develop machine learning models based on collected data	Case Study	PPT Slides Youtube video Online ML platform sensing equipment	8h	- Problem Solving - Critical thinking	Case Study	Task 1	Task 2
Task 2: Analogical sensor sensitivity analysis	- Analogical signal acquisition concepts - Analytic methodology for signal events detection	Case Study	PPT files CSV files	14h	- Problem Solving - Critical thinking	Case Study	Task 2	

Meta Skills							
Module Outcomes	Participants will be able to analyse data collected from digital and analogical sensors						
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Analysis of the reliability of ML algorithms selection, their performance, etc.						
Teaching Material							
Equipment	Thunderboard Sense 2						
Multimedia							
Content URL							
Class requirements *(equipement that participants should bring)*	Computer						
Prerequisites *(previous modules that student should attend)*	Act 5.2	Act 5.3					
Total duration *(Hrs)*	22h						

5.2.2. Act U.3.2 Non-Conformities RCA and Quality gates design

- Objectives: This activity aims at implementing the quality gates concepts for the analysis of electronic ships assembly process using QC data collected from images and transformed in CVS format. The objective is to define the optimal sequence of quality gates to activate when
- Link on the LeL Platform: https://lel.eplus-enhance.eu/course/view.php?id=43

(access credentials are available for EC reviewers)

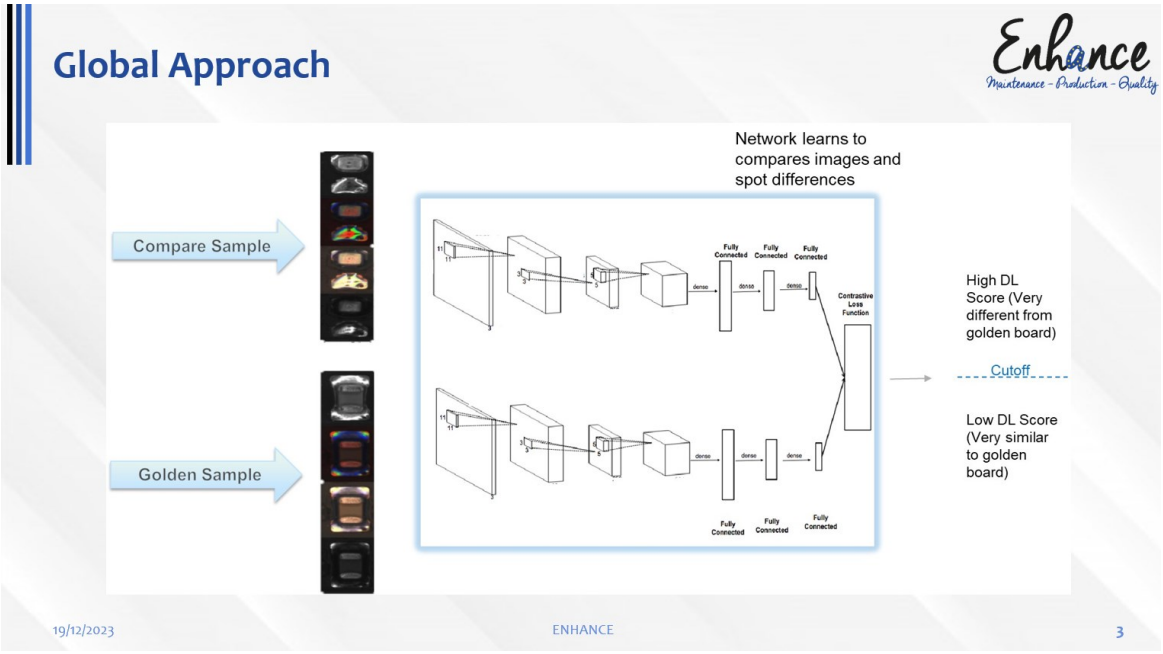

Figure 13: Act U.3.2 Non-Conformities RCA and Quality gates design2 – content example

Enhance Procurement - Production - Quality	**Learning Activity Syllabus**						Co-funded by the Erasmus+ Programme of the European Union
ENHANCE Domain	Quality						
Skill Set	Quality Use Cases						
Activity Title	Non-Conformities RCA and Quality gates design						
Activity Acronym	Act_U3.2						
Activity Description	This activity aims at implementing the quality gates concepts for the analysis of electronic ships assemply process using QC data collected from images and transformed in CVS format. The objective is to define the optimal sequence of quality gates to activate when						
Keywords	Sensors	Design					

Teaching task related to I4.0	**Topics**		**Teaching Plan**				**Learning Path**		
	Hard Skill		**Delivery Method (gamification, case study, simulation...)**	**Teaching Material**	**Duration (Hrs)**	**Soft Skill**	**Assesment**	**If FAIL goes to**	**If PASS goes to**
Task1: Quality Control in Electronics	- Understand defect problems and categories in electronic chips - Analyse quality control data collected at different gates - provide the optimal sequence of quality gates to ensure the quality assurance of chips		Case Study	PPT Slides Youtube video Online ML platform	8h	- Problem Solving - Critical thinking	Case Study	Task 1	

Meta Skills							
Module Outcomes	Participants will be able to develop ML algorithms to define optimal virtual quality gates.						
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Analysis of the reliability of ML algorithms selection, their performance, etc.						
Teaching Material							
Equipment							
Multimedia							
Content URL							
Class requirements *(equipement that participants should bring)*	Computer						
Prerequisites *(previous modules that student should attend)*	Act 5.2	Act 5.3					
Total duration *(Hrs)*	8						

5.2.3. Act U.3.3 IoT and BPM for Integrated VSM

- Objectives: Model, Simulate, Execute, Optimize, Follow a business process
- Link on the LeL Platform: https://lel.eplus-enhance.eu/course/view.php?id=15

(access credentials are available for EC reviewers)

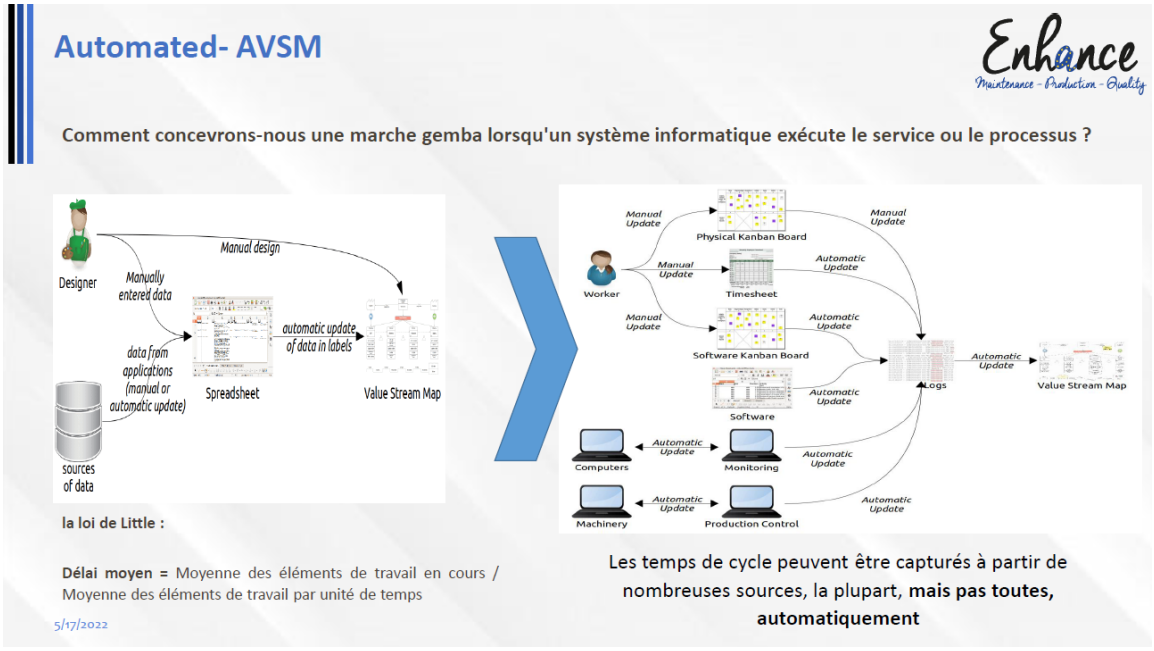

Figure 14: Act U.3.3 IoT and BPM for Integrated VSM– content example

Enhance	**Learning Activity Syllabus**						Co-funded by the Erasmus+ Programme of the European Union
ENHANCE Domain	Quality 4.0						
Skill Set	Advanced Quality strategies						
Activity Title	IoT and BPM for Integrated VSM						
Activity Acronym	Act_U.3.3						
Activity Description	Model, Simulate, Execute, Optimize, Follow a business process						
Keywords	BPM	VSM	MES	IOT	ERP		

Teaching task related to I4.0	**Topics**		**Teaching Plan**				**Learning Path**		
	Hard Skill		**Delivery Method (gamification, case study, simulation...)**		**Teaching Material**	**Duration (Hrs)**	**Soft Skill**	**Assesment**	**If FAIL goes to**	**If PASS goes to**
Task 1 : Business Process Management (BPM)	1- Understand the importance of business processes in the digital factory. 2- Acquire the basic knowledge of BPM and diagramming, and know the basic functionalities of the application.		Presentation and case study		File PPT	4		Test	Task 1	Task 2
Task 2 : IOT	Combination of sustainability management and VSM - Process model for information enriched VSM with MES - Practical feasibility of VSA supported by MES		Presentation and case study		File PPT	4		Case study	Task 2	Task 3
Task 3 : BPMN-IOT FOR VSM - Prise en charge de la conception de VSM à l'aide du BPMS	Understand the concept of pool in-put		Presentation and case study		File PPT	4		Case study	Task 3	
TASK 4: case study in automotive company	APPLICATION TO IOT BPMN VSM		PRESENTATION AND CASE STUDY		SIMULATION VSM					

Meta Skills	Advanced Quality strategies MODELISATION AND SIMULATION						
Module Outcomes	Understand the importance of business processes in the digital factory		Acquire the basic knowledge of BPM and diagramming, and know the basic functionalities of the application.		Combination of sustainable development management and VSM.		Process model for VSM enriched with an information with MES.
Target Group *(students, workers...)*	Master students	Engineering students					
Assessment Method	Project report, Project presentation,						
Teaching Material							
Equipment							
Multimedia	video						
Content URL							
Class requirements *(equipement that participants should bring)*	Computer						
Prerequisites *(previous modules that student should attend)*	ACT 3.1 DDS PPSS	ACT 4.2 VSM4.0	ACT 4.4 DDV	QQM2 BPM VSM			
Total duration *(Hrs)*	12						

5.2.4. Act U.3.4 Process maturity self-assessment and lifecycle management (not developed)

5.2.5. Act U.3.5 Prescriptive and adaptive decision for Quality Control

- Objectives: This use-case provides how the decision-making process is employed to improve the quality of manufacturing process.
- Link on the LeL Platform: https://lel.eplus-enhance.eu/course/view.php?id=27

(access credentials are available for EC reviewers)

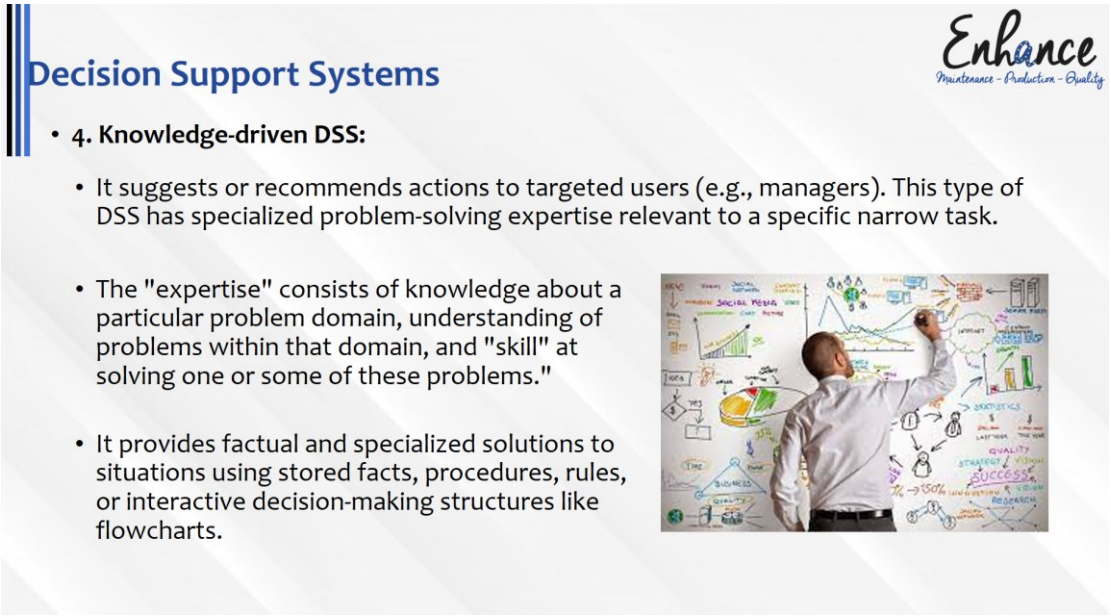

Figure 15: Act U.3.5 Prescriptive and adaptive decision for Quality Control – content example

Enhance	**Learning Activity Syllabus**						Co-funded by the Erasmus+ Programme of the European Union
ENHANCE Domain	Quality 4.0						
Skill Set	Application of ML to support decision making process						
Activity Title	Prescriptive and Adaptive Decision for Quality Control						
Activity Acronym	Act_U3.5						
Activity Description	This use-case provides how the decision making process is employed to improve the quality of manufacturing process.						
Keywords	Decision Support	Machine Learning	Business Analytics				

Teaching task related to I4.0	**Topics**	**Teaching Plan**				**Learning Path**		
	Hard Skill	**Delivery Method (gamification, case study, simulation...)**		**Teaching Material**	**Duration (Hrs)**	**Soft Skill**	**Assesment**	**If FAIL goes to**	**If PASS goes to**
1. Overview of Decision Support Systems	Brief introduction into the decision support systems, including core types of decision support systems. An introduction about Data Sets and its features.	Lecture	Group Discussion	ppt file	20 min.	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	Question 1	Task 3 (MDIS)	task 2 (SND)
2. Practical Example Scenario	In this Practical Example Scenario ML is applied to support the decision making process.	Lecture, Live Demonstration	Group Discussion, Individual Assistance	ppt file, code snippets, dataset	1 h				

Meta Skills							
Module Outcomes	Participants will be able to apply ML to support the decision making process.						
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Project report, Project presentation, Live demonstration						
Teaching Material							
Equipment	Google Colab or Jupyter Notebook						
Multimedia	Lecture notes	Role play scene setup					
Content URL							
Class requirements *(equipement that participants should bring)*	Computer						
Prerequisites *(previous modules that student should attend)*	ACT_6.4						
Total duration *(Hrs)*	1,5 h						

6. Conclusion

For the topic Quality 4.0, 14 activities have been developed. The partners have adopted an iterative development process based on refining the first version of each activity through subsequent cycles. The list of activities reflects the finding from the gap and needs analysis executed based upon the results from the first workshop with industrial stakeholders. Additional Workshops and several discussions have been organised (in industrial plants, with trainers …) to evaluate, refine and validate the gaps and therefore the activity contents needed.