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Enhance
Maintenance – Production – Quality

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Executive summary

This comprehensive deliverable outlines a selection of courses and activities meticulously crafted for the Production Pilot domain within the realm of production engineering. Each component within this compilation is accompanied by a concise objective, illustrative screens, a direct link on the public platform, and a detailed syllabus.

The specialized courses presented herein are tailored to enrich and fortify the knowledge base of professionals and enthusiasts engaged in the dynamic field of production engineering. This compendium serves as a valuable resource, seamlessly integrating theoretical understanding with practical application.

The document serves as a comprehensive guide to various courses within the specified domain, offering a structured overview of the learning framework. Beginning with overarching course objectives, it establishes the educational goals to guide learners. Subsequently, the document presents course activities, analogous to chapters defined in this project as activities, providing a systematic breakdown of the curriculum. Each activity is accompanied by specific objective details, delivering a focused overview of the associated content. To offer a preview of the learner's experience, a series of screenshots per activity are incorporated, providing visual insights into the course's key components. For user-friendly navigation, direct links to each activity on the public learning platform are included, ensuring easy access. The document concludes by presenting a comprehensive and informative general syllabus for each entire course, encapsulating the breadth of knowledge to be acquired throughout the learning journey.

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1. Introduction

This document is developed as part of the ENHANCE project in pilot 2 of production 4.0. The content describes all developed courses and case studies for the topic of Production 4.0, providing a comprehensive overview of the curriculum designed to enhance production in the era of Industry 4.0.

1.1. Purpose of the document

The purpose of this document is to list and describe the developed activities related to Production pilot and their contents. The aim is to present for each activity a short objective, some screens per activity, the link in the public platform and its Syllabus.

1.2. Reference documents

This document is realised based the deliverables D2.1 and D1.5.

1.3. Applicability

This document will be used by Moroccan and Tunisian partners to initiate their strategy for creating Competence Centres and Digital Innovation Hubs. The document is Confidential.

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 Course 1: Production, planning, scheduling and control in industry 4.0
- Section 4 Course 2: Factory 4.0: Concepts, techniques, and application
- Section 5 Course 3: Use case

1.6. List of acronyms

- **CC**: Competence Centre
- **DE**: Digital Europe programme (2021-2027)

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 workshops connectivity. The evolution of Maintenance, Production and Quality Engineering (MPQ 4.0) represents the main application domains where Industry 4.0 produces effective beneficial results.

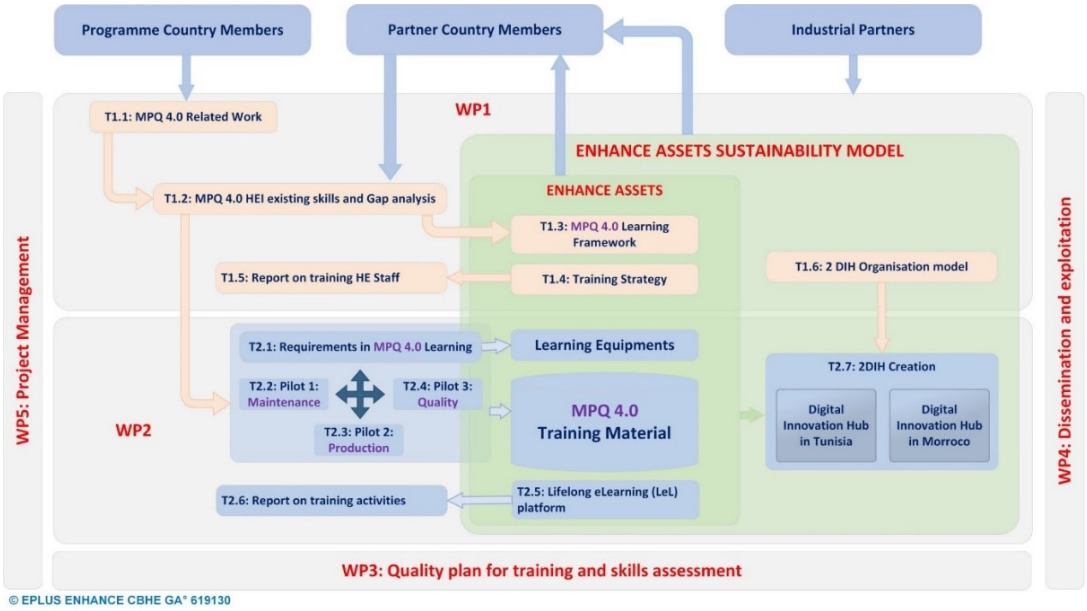

Figure 1. ENHANCE project organization.

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

- 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 : Production, planning, scheduling and control in industry 4.0

3.1. Course objectives

This course aims to equip participants with essential skills and expertise in Industry 4.0, focusing on production, planning, scheduling, and control. The specific competencies targeted in this program include:

- **Design and Development:** Acquiring the ability to design and develop intelligent Production Planning/Scheduling systems.
- **Control Systems in Agile Manufacturing:** Gaining an understanding of the methods and frameworks for control systems in agile manufacturing environments.
- **Data-Driven Models:** Developing familiarity with data-driven planning/scheduling models and algorithms in the context of Industry 4.0.
- **Predictive Inventory Analytics:** Building the capability to conduct predictive inventory analytics using Big Data.

These objectives are related to the used technologies and related new knowledge as defined in D1.1 and presented in the following table.

Table 1 Contribution of main I4.0 technologies to selected production concepts 2

Technologies / **Production Concepts**	IIoT, CPS	BDA	Simulation / Emulation	Cloud/ Edge/ Fog Computing	AI/ML/ DL	AR/VR	Robots/Cobots	Additive Manufacturing	Cyber Security	**Technologies** / **Production Concepts related requirements**
Digital Twin for machine life-cycle Improvement	***	*	***	*	**		***	*	***	Understand machine specification, Use of modelling and simulation tools, Interconnection of systems (Machines/PLC/Sensors /software applications)
Digital Twin for Cyber-Physical Production System Design	***	*	***	*	**	***	***	*	***	Use and selection of appropriate design technique and product development models, perform virtual commissioning,
Dynamic Production Planning	***	***	***	**	***		***	***	**	Use of production planning methods and tools, software development of industrial applications
Decision Support System for continuous production plans evaluation	***	***	**	*	***				***	Familiar with requirements engineering, Expert Systems, artificial intelligence
Data analytics for business intelligence and value creation out of production data	***	***	***	**	***			***	**	Production data handling and fusion techniques

Legend: * (low), ** (intermediate/mitigate), *** (high)

3.2. Presentation of the list of activities

Five activities are offered in the course 1 in order to introduce the Production, planning, scheduling and control in industry 4.0. The list of these activities are:

- Act 3.1: Design and development of smart Production Planning/Scheduling (PPS) systems.
- Act 3.2: Planning and scheduling techniques and approaches in industry 4.0
- Act 3.3: Methods and frameworks for control systems in agile manufacturing
- Act 3.4: Data-driven planning/scheduling models and algorithm
- Act 3.5: Big data and predictive inventory analytics

More details about the content of each activity are presented below.

3.2.1. Act 3.1: Design and development of smart Production Planning/Scheduling (PPS) systems

The activity addresses the key concepts related to the design of smart PSS in the era of industry 4.0.. This involves a thorough exploration of the interconnected aspects and emerging trends relevant to the design of intelligent PSS, considering the advancements and challenges within the broader landscape of Industry 4.0. The aim is to provide a nuanced understanding of the intricate factors influencing the development of smart PSS in the current industrial paradigm.

The course is structured around four key tasks, each contributing to a holistic understanding of modern production processes and leveraging Industry 4.0 advancements. The 4 tasks are the following:

- Task 1: Production Planning Scheduling and Control Systems
- Task 2: PPC in the industry 4.0
- Task 3: Smart PPC Systems
- Task 4: Smart PCC Design and Development Methodology

The figures 2 presents an excerpt of the slides of this activity. In this case this slide relates to the presentation of the main PPC activities.
More information may be found at the learning platform at:
https://lel.eplus-enhance.eu/course/view.php?id=5

(access credentials are available for EC reviewers)

Figure 2. Print screen Act 3.1: Design and development of smart Production Planning/Scheduling (PPS) systems

The content is organized according to the following syllabus:

Enhance	**Learning Activity Syllabus**										
ENHANCE Domain	Production										
Skill Set	Ability to achieve digitalization of modeling & design			Ability to achieve digital transformation, implementation, migration, deployment							
Activity Title	Design and Development of Smart Production Planning/Scheduling Systems										
Activity Acronym	Act_3.1										
Activity Description	The activity adresses the key concepts related to the design of smart PSS in the era of industry 4.0.. This involves a thorough exploration of the interconnected aspects and emerging trends relevant to the design of intelligent PSS, considering the advancements and challenges within the broader landscape of Industry 4.0. The aim is to provide a nuanced understanding of the intricate factors influencing the development of smart PSS in the current industrial paradigm.										
Keywords	PSS	Design		Development	Inustry 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**
Task 1: Production Planning Scheduling and Control Systems	Production planning and control Main PPC Activities Manufacturing Challenges			Presentation and Face-To-Face		ppt file	3	.Critical thinking . Presentation . communication	3 Questions	1	2
Task 2 : PPC in the industry 4.0	Industry 4.0 Objectives PPC Activities & Industry 4.0 Technologies			Presentation and Face-To-Face		ppt file	3	.Critical thinking . Presentation . communication	2 Questions	2	3
Task 3 : Smart PPC Systems	Smart Concept Use Cases Matrix for PPC System Levels & Processes Conceptual Model for Smart PPC Smart Product/Process Strategies			Presentation and Face-To-Face group discussion		ppt file	3	.Critical thinking . Presentation . communication			
Task 4 : Smart PCC Design and Development Methodology	Methodology Principles			Case study		ppt file	4	.Critical thinking . Presentation . Problem solving . communication	2 Questions	4	
Meta Skills											
Module Outcomes	Participants will be able to: - Apply production planning and control (PPC) principles and methodologies to effectively manage and optimize manufacturing processes. -Identify and overcome the challenges faced in manufacturing, such as resource allocation, scheduling, and inventory management, through the implementation of appropriate PPC strategies. Understand and leverage the concepts of Industry 4.0 and smart manufacturing to enhance PPC activities, improve efficiency, and enable real-time decision-making in the production environment.										
Target Group *(students, workers...)*	Master students										
Assessment Method	Project report, Project presentation										
Teaching Material											
Equipment	Simulation software										
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)*	13										

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3.2.2. Act 3.2: Planning and scheduling techniques and approaches in industry 4.0

The activity "Planning and Scheduling in Industry 4.0: Approaches and Techniques," is designed to equip participants with the essential knowledge and skills needed to excel in the contemporary landscape of manufacturing, focused on the pivotal role of planning and scheduling in Industry 4.0. The objective is thus to give participants the needed expertise to strategically plan and schedule in Industry 4.0 environments, fostering adaptive and resilient manufacturing operations. The acquired knowledge will empower professionals to play a crucial role in enhancing productivity and competitiveness within the context of Industry 4.0.

The content is organized into three tasks labelled:

- Task 1: Current state of production planning and scheduling,
- Task 2: Cloud manufacturing
- Task 3: Planning and Scheduling in cloud manufacturing

The figures 3 presents an example of the slides of this activity. In this slide, the main objectives of current state of production planning and scheduling are explained.

More information may be found at the learning platform at:

https://lel.eplus-enhance.eu/course/view.php?id=33
(access credentials are available for EC reviewers)

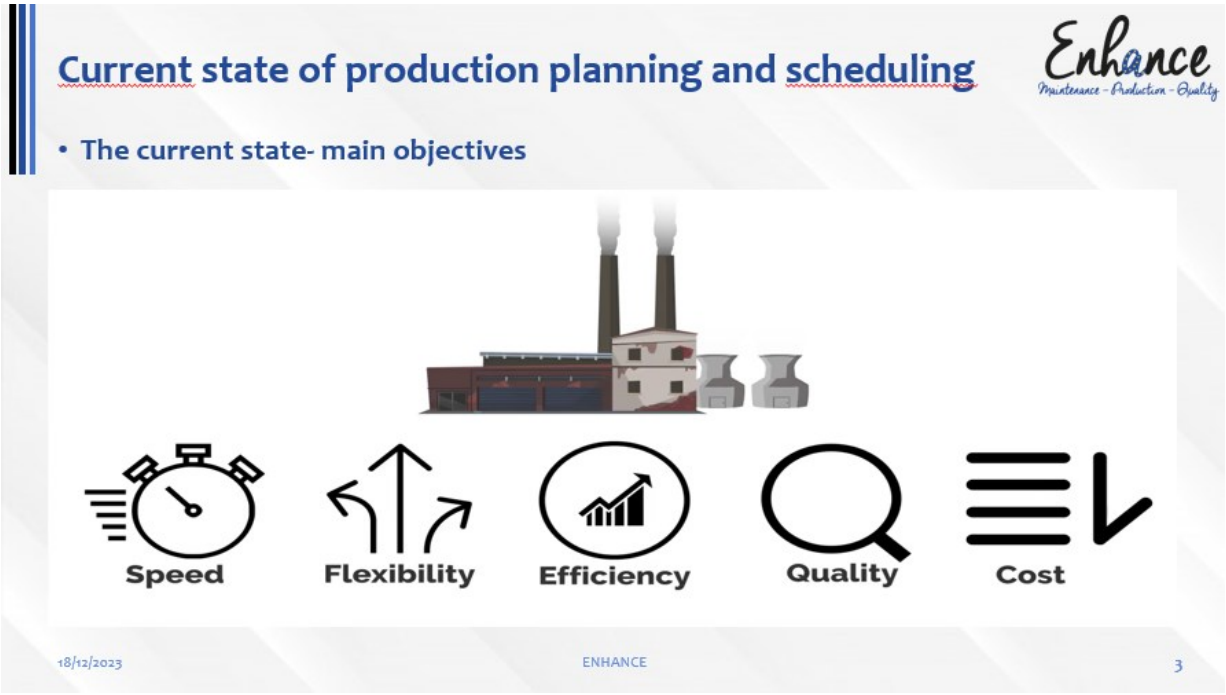

Figure 3 Print screen Act 3.2: Planning and scheduling techniques and approaches in industry 4.0

The content is organized according to the following syllabus:

Enhance	**Learning Activity Syllabus**					Co-funded by the Erasmus+ Programme of the European Union	
ENHANCE Domain	Production						
Skill Set	Skill 6.3: Ability to make prescriptive and adaptive decisions		Skill 5.1: Ability to manage DIK and related infrastructure				
Activity Title	Planning and scheduling techniques and approaches in industry 4.0 and cloud manufacturing						
Activity Acronym	Act_3.2						
Activity Description	The activity "Planning and Scheduling in Industry 4.0: Approaches and Techniques," is designed to equip participants with the essential knowledge and skills needed to excel in the contemporary landscape of manufacturing, focused on the pivotal role of planning and scheduling in Industry 4.0. The objective is thus to give participants the needed expertise to strategically plan and schedule in Industry 4.0 environments, fostering adaptive and resilient manufacturing operations. The acquired knowledge will empower professionals to play a crucial role in enhancing productivity and						
Keywords	production planning	production scheduling	Cloud manufacturing	cloud 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**
Tasks 1: Current state of production planning and scheduling	MRP, ERP, production scheduling algorithms		presentation		ppt file	1h	Critical thinking	question 1	task1	task2
Task 2: Cloud manufacturing	cloud computing, cloud manufacturing		presentation		ppt file	1h	Critical thinking	question2	task2	task3
Task 3: Planning and Scheduling in cloud manufacturing	cloud ERP		presentation	case study	ppt file, cloud	3h	Critical thinking	Q3, case study	task1	

Meta Skills							
Module Outcomes	Participants will be able to plan production using cloud manufacturing (cloud ERP,...)		Participants will be able to schedule production using cloud manufacturing				
Target Group *(students, workers...)*	Master students	SME personnels	engineering students				
Assessment Method	Project report, Project presentation, test, use case						
Teaching Material							
Equipment	Cloud server						
Multimedia							
Content URL							
Class requirements *(equipement that participants should bring)*	cloud ERP						
Prerequisites *(previous modules that student should attend)*	cloud computing/ cloud manufacturing, production scheduling algorithms, production planning methods, ERP						
Total duration *(Hrs)*	5						

3.2.3. Act 3.3: Methods and frameworks for control systems in agile manufacturing

This activity aims to exploring various methods and frameworks for implementing control systems in agile manufacturing. It includes control methodologies such as lean manufacturing, Six Sigma, and Kanban to improve flexibility, responsiveness, and efficiency in production processes.

This activity contains 7 tasks as follows:

- Task 1: Definitions, principles and types of Kanban
- Task 2: How to build a Kanban system?
- Task 3: Push vs pull production systems
- Task 4: Scrum Methodologies
- Task 5: Conwip, polca and cobacabana
- Task 6: Developments in the pull-flow management of production systems
- Task 7: E-kanban implementation

The figures 4 presents an excerpt of the slides of this activity. In this case this slide relates to the presentation of the CONWIP Production Control-System.

More information may be found at the learning platform at:

https://lel.eplus-enhance.eu/course/view.php?id=35

(access credentials are available for EC reviewers)

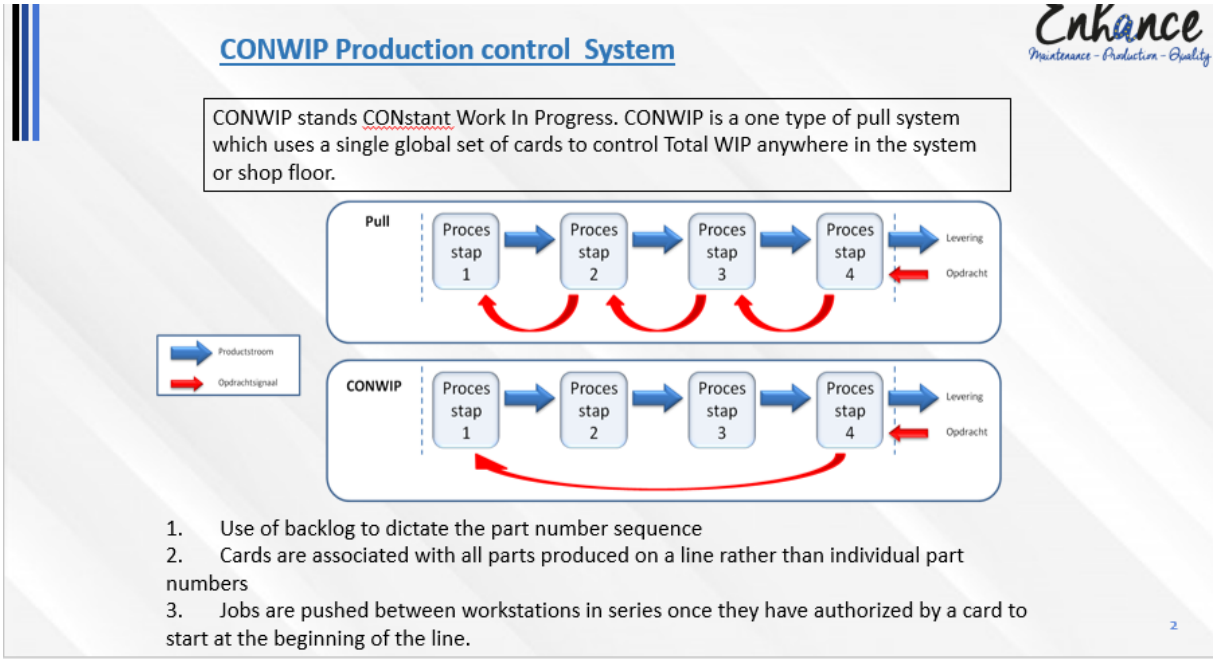

Figure 4 Print screen Act 3.3: Methods and frameworks for control systems in agile manufacturing

The content is organized according to the following syllabus:

Enhance	**Learning Activity Syllabus**						Co-funded by the Erasmus+ Programme of the European Union
ENHANCE Domain	Production 4.0						
Skill Set							
Activity Title	Act 3.3: Methods and frameworks for control systems in agile manufacturing						
Activity Acronym	Act_3.3						
Activity Description	This activity focuses on exploring various methods and frameworks for implementing control systems in agile manufacturing. It includes studying and applying control methodologies such as lean manufacturing, Six Sigma, and Kanban to improve flexibility, responsiveness, and efficiency in production processes. The activity aims to develop a comprehensive understanding of control systems and their application in the context of agile manufacturing.						
Keywords	control system	agile manufacturing	lean manufacturing	six sigma	kanban	process control	

Topics / Teaching Plan	**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: Definitions,principles and types of Kanban	Kanban board management, visual workflow optimization, inventory control, continuous improvement.	presentation	ppt file	2h	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	MCQ	Iterate Task 1	Task2
task 2: How to build a Kanban system?	Workflow analysis, task prioritization, visual management, team collaboration.	presentation	ppt file	3h	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	MCQ	Iterate Task 2	Task3
task 3: Push vs pull production systems	Demand forecasting, production planning, inventory management, supply chain coordination.	presentation	ppt file	2h	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	MCQ	Iterate Task 3	Task4
task 4: Scrum Methodologies	Agile project management, sprint planning, backlog management, cross-functional collaboration.	presentation	ppt file	2h	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	MCQ	Iterate Task 4	Task 5
task 5: Conwip,polca and cobacabana	Work-in-progress control, production sequencing, capacity planning, shop floor coordination.	presentation	ppt file	2h	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	MCQ	Iterate Task 5	Task 6
task 6: Evolution du pilotage en flux tirés des systèmes de production	Lean manufacturing, kanban implementation, continuous improvement, value stream mapping.	presentation	ppt file	2h	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	MCQ	Iterate Task 6	Task 7
task 7: Implémentation E-kanban	Electronic inventory management, RFID technology, system integration, data analysis.	presentation	ppt file	2	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	MCQ	Iterate Task 7	Go to subsequent activity

Meta Skills	To be an Agile Manufacturing Systems Engineer.						
Module Outcomes	Apply lean manufacturing principles and practices, Utilize Six Sigma methodologies for process improvement, Implement Kanban systems for visual management and inventory control,Design and implement effective control systems, Analyze process data using statistical tools. Integrate control systems with automation and digital technologies. Apply project management skills for successful implementation. Collaborate effectively in cross-functional teams. Stay updated with advancements in control systems for agile manufacturing.						
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Multiple choice questions						
Equipment							
Multimedia	Lecture notes	Role play scene setup					
Content URL	Video URL						
Class requirements *(equipement that participants should bring)*	Computer						
Prerequisites *(previous modules that student should attend)*							
Total duration *(Hrs)*	13						

3.2.4. Act 3.4: Data-driven planning/scheduling models and algorithms

This activity aims to enhance participants' abilities in data analysis, mathematical modelling, and algorithm development for improved efficiency and decision-making in planning and scheduling. It focuses on cultivating a deep understanding of data-driven insights, creating sophisticated mathematical models, and refining algorithms to address dynamic challenges. Ultimately, participants will develop multifaceted skills that empower them to navigate the complexities of modern planning and scheduling, fostering proactive and analytical decision-making for operational efficiency.
The content is organized into three tasks labelled:

- Task 1: Data driven for Smart factory
- Task 2: A practical example of the implementation of Industry 4.0 technologies
- Task 3: How do you develop a control system for planning and scheduling?

The figures 5 presents one slide from those offered for this activity as an example. The slide presents the data driven planning and scheduling.

More information may be found at the learning platform at:

https://lel.eplus-enhance.eu/course/view.php?id=28
(access credentials are available for EC reviewers)

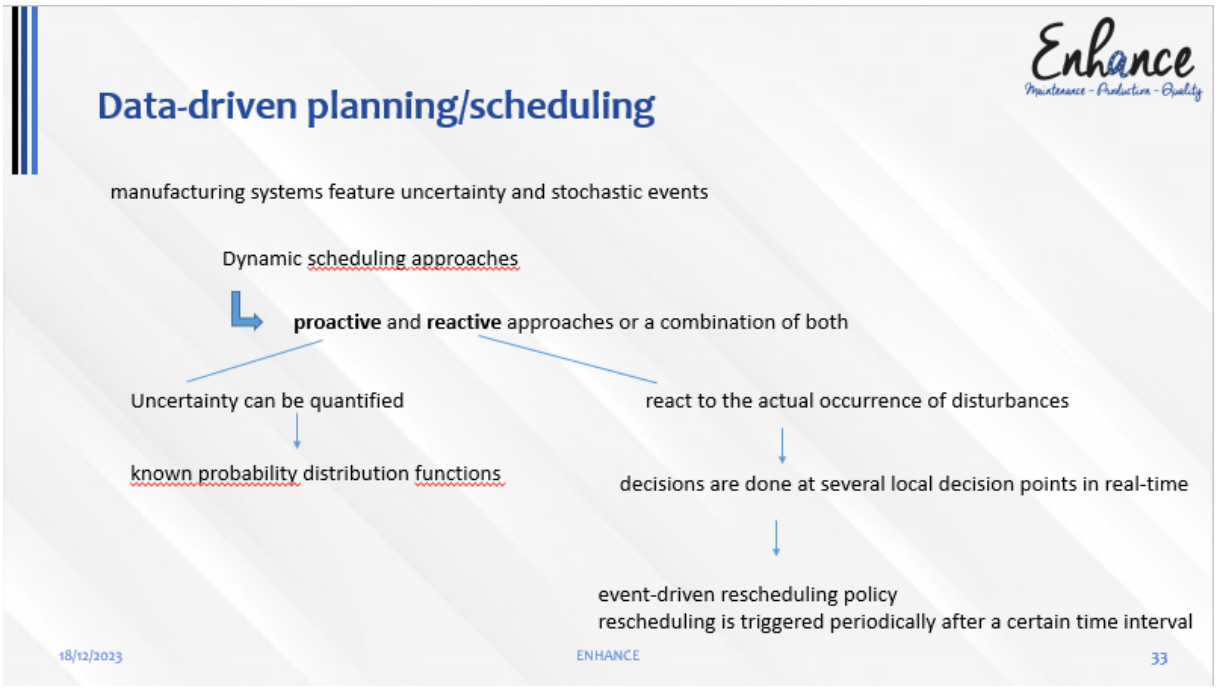

Figure 5 Print screen Act 3.4: Data-driven planning/scheduling models and algorithms

The content is organized according to the following syllabus:

Enhance Maintenance - Production - Quality	**Learning Activity Syllabus**						Co-funded by the Erasmus+ Programme of the European Union
ENHANCE Domain	production 4.0						
Skill Set							
Activity Title	Act 3.4: Data-driven planning/scheduling models and algorithms						
Activity Acronym	Act_3.4						
Activity Description	This activity aims to enhance participants' abilities in data analysis, mathematical modeling, and algorithm development for improved efficiency and decision-making in planning and scheduling. It focuses on cultivating a deep understanding of data-driven insights, creating sophisticated mathematical models, and refining algorithms to address dynamic challenges. Ultimately, participants will develop multifaceted skills that empower them to navigate the complexities of modern planning and scheduling, fostering proactive and analytical decision-making for operational efficiency.						
Keywords	Data-driven	Planning	Scheduling				

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 : Data driven for Smart factory	Data analysis, Machine learning, Programming, Statistical modeling, Optimization, Visualization, Predictive modeling, Decision-making, Process automation, Data-driven decision-making.		presentation			2	Analytical thinking Problem-solving Collaboration Adaptability Attention to detail Time management Continuous learning	MCQ	Task 1	task 2
Task 2 : Un exemple pratique de l'implémentation des technologies de l'industrie 4.0	Connectivity, Automation, IoT, Robotics, Big Data Analytics, Artificial Intelligence, Cybersecurity, Digital Twin, Augmented Reality.		presentation			2,5	Analytical thinking Problem-solving Collaboration Adaptability Attention to detail Time management Continuous learning	project report/presentation		
Task 3 : Comment développer un système de pilotage pour la planification et l'ordonnancement?	data Data analysis, Mathematical modeling, Algorithm development, Process optimization, System integration, Testing and validation, Continuous improvement.		presentation			2,5	Analytical thinking Problem-solving Collaboration Adaptability Attention to detail Time management Continuous learning	project report/presentation		

Meta Skills	To be a: Planning Analyst,Scheduling Coordinator, Supply Chain Planner, Operations Research Analyst, Production Scheduler.						
Module Outcomes	Participants will be able to make informed decisions using data-driven models/algorithms,		Participants will be able to Improve efficiency through data-driven planning/scheduling				
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Multiple choice question, Project report, Project presentation						
Teaching Material							
Equipment							
Multimedia							
Content URL							
Class requirements *(equipement that participants should bring)*	Arena : simulation program						
Prerequisites *(previous modules that student should attend)*	Data acquisition and analysis						
Total duration *(Hrs)*	7						

3.2.5. Act 3.5: Big data and predictive inventory analytics

This activity explores typical challenges in inventory management, examining issues such as overstocking and stockouts. It emphasizes the application of machine learning techniques to address these challenges, particularly in the context of handling Big Data. Participants will gain insights into how advanced algorithms optimize inventory processes. The focus is on real-time analysis, enabling informed decision-making and improved accuracy in inventory predictions. Ultimately, the activity aims to equip individuals with skills to effectively leverage machine learning for enhanced inventory management.

This activity contains three tasks as follows:

- Task 1. Fundamentals in Data analytics and production planning.
- Task 2. Big Data Analytics for Inventory Management.
- Task 3. Industry 4.0 supporting solutions for advanced Inventory Systems

The figures 6 provide an excerpt of the slides of this activity. In this slide, the importance of inventory control is discussed with details.

More information may be found at the learning platform at:
https://lel.eplus-enhance.eu/course/view.php?id=17
(access credentials are available for EC reviewers)

Figure 6 Print screen Act 3.5: Big data and predictive inventory analytics

The content is organized according to the following syllabus:

Enhance Productivity - Production - Quality	**Learning Activity Syllabus**						Co-funded by the Erasmus+ Programme of the European Union
ENHANCE Domain	Production 4.0						
Skill Set	Ability to understand advanced inventory strategies						
Activity Title	Big data and predictive inventory analytics						
Activity Acronym	Act_3.5						
Activity Description	This activity explores typical challenges in inventory management, examining issues such as overstocking and stockouts. It emphasizes the application of machine learning techniques to address these challenges, particularly in the context of handling Big Data. Participants will gain insights into how advanced algorithms optimize inventory processes. The focus is on real-time analysis, enabling informed decision-making and improved accuracy in inventory predictions. Ultimately, the activity aims to equip individuals with skills to effectively leverage machine learning for enhanced inventory management.						
Keywords	Inventory	BigData	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**
1. Fundamentals in Data analytics and production planning	Understanding of basic concepts realted with invnetory, understanding of the landscape of approaches utilized in inventory, core types of inventory systems	Lecture	Group Discussion	.ppt file	1h	.Critical thinking .Presentation .Infographic communication	Question 1	Task 3 (MDIS)	task 2 (SND)
2. Big Data Analytics for Inventory Management	Understanding of BigData importance, challenges and opportunities within inventory management, application examples of ML in inventory management	Lecture	Group Discussion	.ppt file	1h	.Critical thinking .Presentation .Infographic communication			
3. Industry 4.0 supporting solutions for advanced Inventory Systems	Analysis and Impact of Industry 4.0 in production planning, introduction of Dynamic Networks concept	Lecture	Group Discussion	.ppt file	1h	.Critical thinking .Presentation .Infographic communication			

Meta Skills							
Module Outcomes	Participants will be able to distinguish different invnetory management systems.		Participants will explore the invnetroy problems that can be adressed by ML.		Participants will understand the role of BigData in inventory management.		
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. Course 2 : Factory 4.0: Concepts, techniques, and application

4.1. Course objectives

This course's primary objective is to furnish participants with essential knowledge related to production encompassing concepts, techniques, and applications within Industry 4.0, with at first a particular focus on PLM and Digital Factory integration. Then, it aims to cover VSM 4.0 principles, exploring the role of Virtual Reality for simulation and key performance indicators (KPIs). Additionally, the course will delve into the significance of Dashboarding and data visualization in the context of Industry 4.0, providing participants with a comprehensive understanding of these integral components. Overall, the goal is to equip individuals with the requisite skills to navigate and contribute effectively to the industry 4.0 landscape through a multifaceted approach.

Thus, the specific competencies targeted in this course are related to:

- **PLM and Digital Factory**: Acquiring the ability to design and develop PLM and Digital Factory
- **VSM 4.0**: Building the capability to develop and update a VSM 4.0
- **Virtual Reality for simulation:** Gaining an understanding of the methods of simulation using virtual reality.
- **KPI, Dashboarding and data visualization:** Developing skills to design dashboarding and methods for visualizing data.

4.2. Presentation of the list of activities

Four activities are provided in the course 1 in order to present the different concepts, techniques, and applications in Factory 4.0. The offered activities are the following.

- Act 4.1: PLM and Digital Factory.
- Act 4.2: VSM for production 4.0
- Act 4.3: Virtual Reality for simulation
- Act 4.4: KPI, Dashboarding and data visualization.

More details about the content of each activity are presented below.

4.2.1. Act 4.1: PLM and Digital Factory

The primary focus of this activity is to empower participants with essential knowledge for effective management of product data and processes throughout their entire lifecycle. It delves into the concept of Digital Factory, where participants will explore the strategic implementation of digital technologies to optimize manufacturing processes and significantly enhance overall productivity. Through this comprehensive exploration, participants will gain insights into leveraging advanced digital tools for efficient product lifecycle management. The activity aims to bridge the gap between theory and practical application, equipping individuals with the skills necessary to navigate the dynamic landscape of Digital Factory methodologies. Ultimately, participants will be well-prepared to contribute to improved manufacturing efficiency and innovation within the evolving context of modern industrial processes.

Seven tasks are delivered into this activity which are:

- Task 1: PLM definition and concepts.

- Task 2: Reasons to adopt Product Lifecycle Management.
- Task 3: PLM functionalities.
- Task 4: PLM: relation to other systems and tools.
- Task 5: PLM: integrated methods, tools and systems.
- Task 6: Architecture of Integration PLM, MES and ERP.
- Task 7: Enabling technologies for system integration: PLM and Digital twin technology

The figures 7 provide an excerpt of the slides of this activity. In this slide, The PLM definition and concepts are explained with details.

More information may be found at the learning platform at:

https://lel.eplus-enhance.eu/course/view.php?id=8

(access credentials are available for EC reviewers)

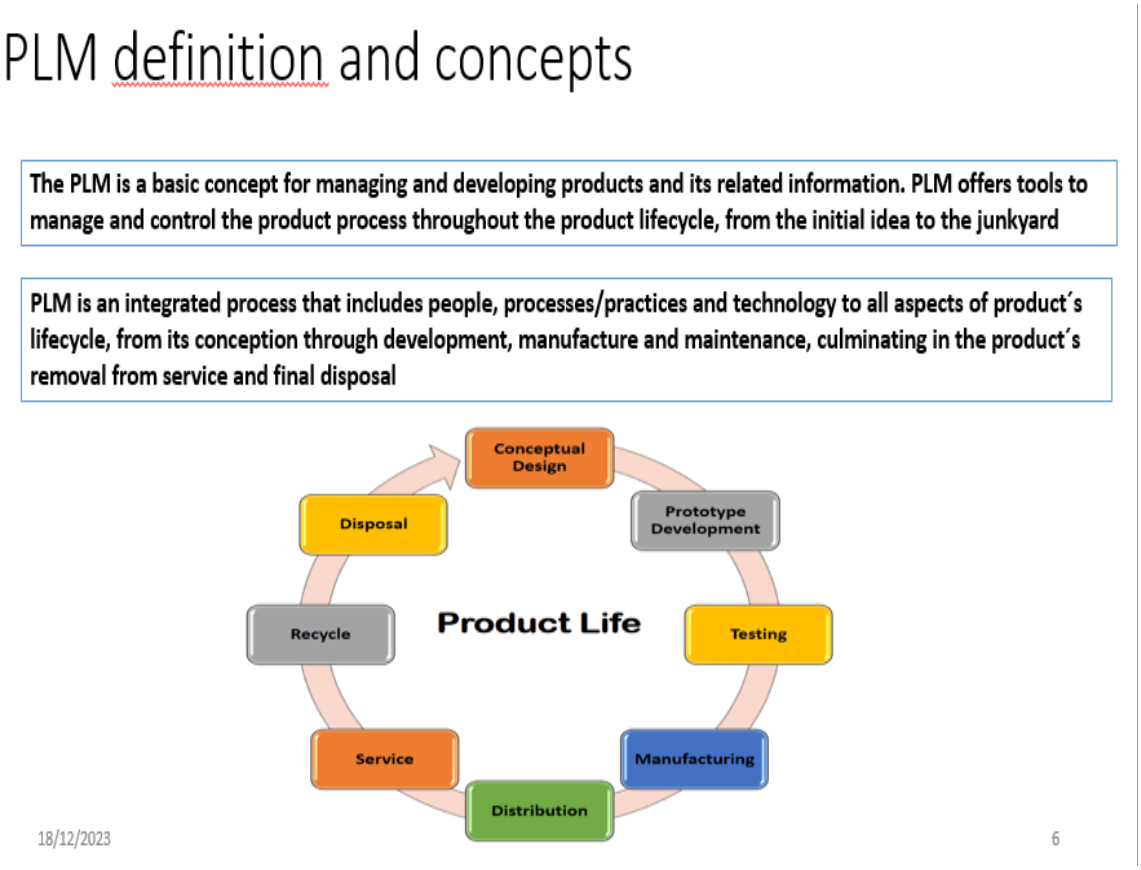

Figure 7. Print screen Act 4.1: PLM and Digital Factory

The content is organized according to the following syllabus:

Enhance	**Learning Activity Syllabus**					Co-funded by the Erasmus+ Programme of the European Union
ENHANCE Domain	Production 4.0					
Skill Set	Factory 4.0: Concepts, techniques, and application					
Activity Title	Act 4.1: PLM and Digital Factory					
Activity Acronym	Act_4.1					
Activity Description	The primary focus of this activity is to empower participants with essential knowledge for effective management of product data and processes throughout their entire lifecycle. It delves into the concept of Digital Factory, where participants will explore the strategic implementation of digital technologies to optimize manufacturing processes and significantly enhance overall productivity. Through this comprehensive exploration, participants will gain insights into leveraging advanced digital tools for efficient product lifecycle management. The activity aims to bridge the gap between theory and practical application, equipping					
Keywords	Data Integration	Product Lifecycle Management	Automation, IoT, Robotics,		Data Analytics.	

Teaching task related to I4.0		**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 : PLM definition and concepts	PLM software proficiency, product development knowledge, data management, change management, collaboration.	presentation		ppt file	2	Problem Solving Critical thinking infographic communication	MCQ	Iterate Task 1	Task2
Task 2 : Raisons d'adopter le Product Lifecycle Management	PLM software proficiency, product development knowledge, data management, change management, collaboration.	presentation		ppt file	2	Problem Solving Critical thinking infographic communication	MCQ	Iterate Task 2	Task3
Task 3 : Les fonctionnalités d'un PLM	PLM software proficiency, data management, BOM management, change management, collaboration.	presentation		ppt file	2	Problem Solving Critical thinking infographic communication	MCQ	Iterate Task 3	Task4
Task 4 : PLM : relation to other systems and tools	Integration expertise, system interoperability, tool compatibility, data exchange proficiency.	presentation		ppt file	2	Problem Solving Critical thinking infographic communication	MCQ	Iterate Task 4	Task 5
Task 5 : PLM : integrated methods, tools and systems	Method integration, tool proficiency, system interoperability, data synchronization.	presentation		ppt file	2	Problem Solving Critical thinking infographic communication	MCQ	Iterate Task 5	Task 6
Task 6 : Architecture of Integration PLM, MES and ERP	Integration architecture expertise, system interoperability, data mapping, workflow configuration.	presentation		ppt file	2	Problem Solving Critical thinking infographic communication	MCQ	Iterate Task 6	Task 5
Task 7 : Enabling technologies for system integration : PLM and Digital twin technology	Digital twin proficiency, PLM software expertise, data synchronization, system integration.	presentation		ppt file	2	Problem Solving Critical thinking infographic communication	MCQ	Iterate Task 6	Go to subsequent activity

Meta Skills	to be a To be a PLM Analyst						
Module Outcomes	Participants will be able to implement PLM systems and optimize digital factory processes.						
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Multiple choice questions						
Teaching Material							
Equipment							
Multimedia							
Content URL							
Class requirements *(equipement that participants should bring)*	Computer						
Prerequisites *(previous modules that student should attend)*	ERP, SCM, Planning and Scheduling						
Total duration *(Hrs)*	14						

4.2.2. Act 4.2: VSM for production 4.0

This activity aims to provide participants with an in-depth comprehension of the principles and applications of Automated Value Stream Mapping within the framework of Production 4.0. The activity target to give participants the Key concepts, methodologies, and the methods of integration of Automated VSM in modern production processes, utilizing Manufacturing Execution System (MES) data. Emphasis will be placed on the utilization of real-time data to create dynamic and adaptive value stream maps and use simulation techniques to improve production process in the era of Industry 4.0.

The content is structured into three tasks to facilitate a systematic learning experience:

The content is organized according to three tasks as follows:

- Task 1: Introduction on the Automated VSM for production 4.0.
- Task2: Design a VSM using MES data.
- Task3: Design a VSM for simulation.

The figures 8 presents one slide from the overall offered content. In this slide, the automated VSM for production 4.0 is defined and explained.

More information may be found at the learning platform at:

https://lel.eplus-enhance.eu/course/view.php?id=29
(access credentials are available for EC reviewers)

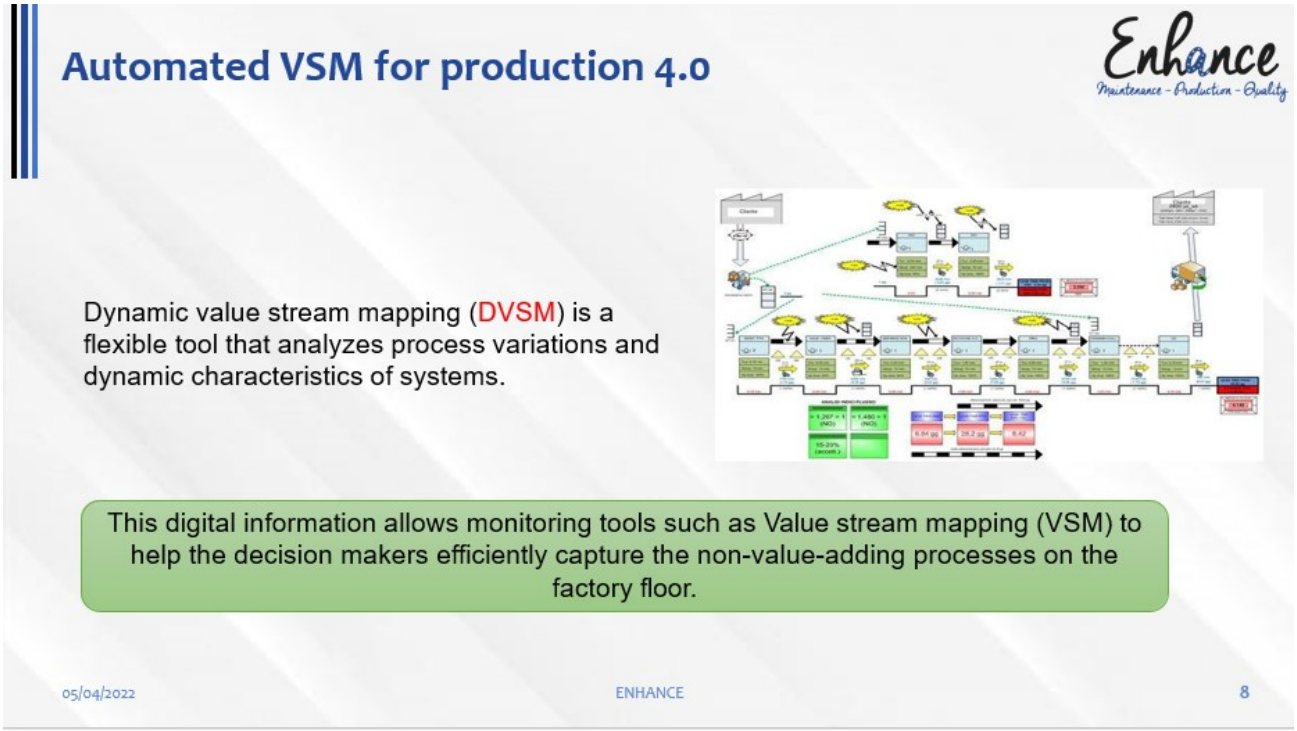

Figure 8. Print screen Act 4.2: VSM for production 4.0

The content is organized according to the following syllabus:

Learning Activity Syllabus

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

ENHANCE Domain	Production						
Skill Set	Ability to link enterprise strategy to manufacturing capabilities			Ability to achieve digitalization of modeling & design	Ability to achieve digital transformation,		
Activity Title	VSM for production 4.0						
Activity Acronym	Act_4.2						
Activity Description	This activity aims to provide participants with an in-depth comprehension of the principles and applications of Automated Value Stream Mapping within the framework of Production 4.0. The activity target to give participants the Key concepts, methodologies, and the methods of integration of Automated VSM in modern production processes, utilizing Manufacturing Execution System (MES) data. Emphasis will be placed on the utilization of real-time data to create dynamic and adaptive value stream maps and use simulation techniques to improve production process in the era of Industry 4.0.						
Keywords	VSM	Data acquisition	VSM-MES				

Teaching task related to I4.0	**CSM-AES**	**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	Relevance of Automated VSM for production 4.0	Presentation and Face-To-Face	ppt file	1	.Critical thinking . Presentation . communication	2 Questions	1	2
Task2: Design a VSM using MES data	MES data collection VSA / VSD Automated VSM using MES data Obtained VSM	Presentation and Face-To-Face	ppt file	3	.Critical thinking . Presentation . communication	2 Questions	2	3
Task3: Design a VSM for simulation	VSM Simulation Digital VSM Discrete event simulation model developed in Extendsim Scenarios to increase the throughput	Presentation and Face-To-Face Project	ppt file	3	.Critical thinking . Presentation . communication	2 Questions	2	

Meta Skills							
Module Outcomes	Participants will be able to -Develop and utilize a Discrete Event Simulation model in Extendsim to simulate and analyze the performance of the value stream within a manufacturing system. - Explore different scenarios within the simulation model to identify strategies and improvements that can increase throughput and overall efficiency. - Apply the knowledge and techniques gained to effectively utilize Automated VSM, MES data, and simulation tools to optimize production processes, reduce lead times, and improve overall productivity in a production 4.0 environment.						
Target Group *(students, workers...)*	Master students						
Assessment Method	Project report, Project presentation						
Teaching Material							
Equipment	Computer	Learning Factory					
Multimedia	Lecture notes						
Content URL							
Class requirements *(equipement that participants should bring)*	Computer						
Prerequisites *(previous modules that student should attend)*							
Total duration *(Hrs)*	7						

4.2.3. Act 4.3: Virtual Reality for simulation

The objective of this activity is to introduce the concepts, techniques of simulation industry 4.0. production is one field among others where these technologies can help the worker, the know-how of a remote expert, virtual training environment and all the useful information at the right time and in the right place in front of his eyes to carry out his task.

Five tasks are delivered into this activity which are:

- Task 1: Definition and overview of Virtual Reality (VR).
- Task 2: Industrial applications of Virtual Reality.
- Task3: Benefits of using Virtual Reality in industrial processes.
- Task4: Challenges and limitations of Virtual Reality in simulating industrial processes.
- Task 5: Application in high education

The figures 9 presents an example of the content of this activity. This slide illustrates the exploitation of virtual reality in the context of Industry 4.0.

More information may be found at the learning platform at:

https://lel.eplus-enhance.eu/course/view.php?id=46
(access credentials are available for EC reviewers)

Figure 9. Print screen Act 4.3: Virtual Reality for simulation

The content is organized according to the following syllabus:

Learning Activity Syllabus

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

ENHANCE Domain	Production 4.0									
Skill Set	Factory 4.0 : Concepts, techniques, and application									
Activity Title	Virtual Reality to simulate industrial process									
Activity Acronym	Act_4.3									
Activity Description	This activity introduces the concepts ,techniques of simulation industry 4.0 . production is one field among others where these technologies can provide assistance to the worker, the know-how of a remote expert, virtual training environment and all the useful information at the right time and in the right place in front of his eyes to carry out his task.									
Keywords	virtual reality VR	Higher education.								
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:Definition and overview of Virtual Reality (VR)	Be able to: - Explanation of Virtual Reality technology - Importance of Virtual Reality in various industries		lecture	Illustration by videos	power point slides White papers	1H	.Critical thinking . Presentation			
Task 2: Industrial applications of Virtual Reality	Be able to applicate: - Training and education in industrial processes - Design and prototyping of industrial products - Remote maintenance and troubleshooting		lecture	Illustration by videos	power point slides	1H	.Critical thinking . Presentation			
Task3: Benefits of using Virtual Reality in industrial processes	Be able to: - Enhanced safety and risk reduction - Improved productivity and efficiency - Cost reduction and time savings		lecture	discussion barinstorming	power point slides Report on VR startups	1H	.Critical thinking . Presentation			
Task4: Challenges and limitations of Virtual Reality in simulating industrial processes	Be able to: - High costs and technical requirements - Limited realism and sensory feedback - Adaptation and user acceptance		lecture	discussion barinstorming	power point slides Report on VR startups	1H	.Critical thinking . Presentation			
task 5: Application hight education	to be able to : -Learn and collaborate in immersive environments -Visualize complex data in 3D -Better prepare students for professional experiences -Objectively measure student and participant performance		case study	discussion barinstorming	Headset Oculus	4H	demonstration			
Module Outcomes										
Target Group *(students, workers...)*	Master students	SME personnels	Teachers/trainers							
Assessment Method										
Teaching Material										
Equipment	tablet	smartphone	PC+webcam	Microcontroller ESP82266	Smart factory Fischertechnic	Headset Oculus				
Multimedia	videos									
Content URL	Video URL									
Class requirements *(equipement that participants should bring)*	Personnel computer									
Prerequisites *(previous modules that student should attend)*	IOT									
Total duration *(Hrs)*	12									

4.2.4. Act 4.4: KPI, Dashboarding and data visualisation

This course aims to provide the essential knowledge and skills to effectively utilize Key Performance Indicators (KPIs) in the context of Industry 4.0. Participants will learn how to design, implement, and monitor KPIs using advanced technologies and a holistic approach to drive performance improvement in manufacturing processes.

The content is organized according to three tasks defined as follows:

- Task1: KPIs for Production 4.0.
- Task2: Manufacturing Dashboards 4.0.
- Task3: Data visualization.

The figures 10 is a Print screen of one slide from those developed in this activity. This slide presents some examples of data visualities using Python.

More information may be found at the learning platform at:

https://lel.eplus-enhance.eu/course/view.php?id=23

(access credentials are available for EC reviewers)

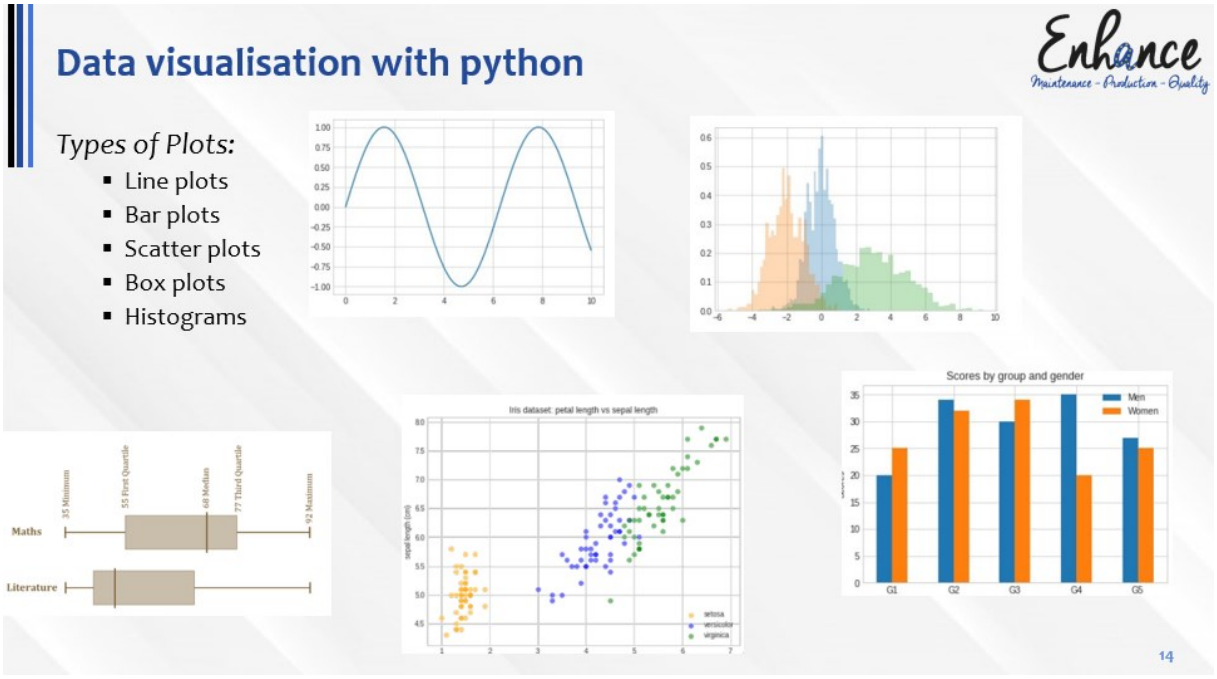

Figure 10. Print screen Act 4.4: KPI, Dashboarding and data visualisation

The content is organized according to the following syllabus:

Enhance – Maintenance – Production – Quality	**Learning Activity Syllabus**						Co-funded by the Erasmus+ Programme of the European Union
ENHANCE Domain	Production						
Skill Set	Data processing & analysis		Ability to analyse and understand the past				
Activity Title	KPI, Dashboarding and data visualisation						
Activity Acronym	Act_4.4						
Activity Description	This course provides participants with the essential knowledge and skills to effectively utilize Key Performance Indicators (KPIs) in the context of Industry 4.0. Participants will learn how to design, implement, and monitor KPIs using advanced technologies and a holistic approach to drive performance improvement in manufacturing processes.						
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: KPIs for Production 4.0	KPIs Principles & Standards KPIs for Data Analytics KPI Lifecycle & Technologies 4.0 KPIs Classes in Industry 4.0 A holistic Approach for Designing KPIs 4.0	Presentation and Face-To-Face		ppt file	3	.Critical thinking . Presentation . communication	MCQ	1	2
Task2: Manufacturing Dashboards 4.0	What are manufacturing dashboards ? Types of dashboards Process dashboards for manufacturing Dashboard Components and functions Production Design Dashboards	Presentation and Face-To-Face		ppt file	3	.Critical thinking . Presentation . communication	MCQ and project	2	3
Task3: Data visualisation	Dashboarding, Reporting, Visualisation Data visualisation with python Visualisation and dashboarding with PowerBI	Presentation Face-To-Face Project		ppt file and training datasets	3	.Critical thinking . Presentation . communication			

Meta Skills							
Module Outcomes	Participants will be able to - Employ PowerBI as a tool for data visualization and dashboarding, enabling them to create dynamic and interactive dashboards that effectively communicate insights from manufacturing data, - Understand the role of data visualization in enhancing data analysis and decision-making processes, and utilize Python to create visually compelling representations of manufacturing data, - Apply the knowledge and skills gained in dashboarding, reporting, and visualization to design production-specific dashboards that provide real-time monitoring and analysis of key production metrics, facilitating better decision-making and performance improvement in manufacturing.						
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Project report, Project presentation, Assessment rubric for teamwork						
Teaching Material							
Equipment	Server						
Multimedia	Lecture notes						
Content URL							
Class requirements *(equipement that participants should bring)*	Computer	powerBi or tableau	Jupyter				
Prerequisites *(previous modules that student should attend)*	Data acquisition and analysis						
Total duration *(Hrs)*	9						

5. Use cases associated to Production 4.0

5.1. Course objectives

This course seeks to enhance participants' skills and expertise in Industry 4.0 production through practical activities and real-world use cases. It specifically targets competencies related to key thematic areas. These include the practical application of contemporary production methods, navigating the dynamic landscape of modern industrial production, and fostering expertise in key areas relevant to Industry 4.0. Through a hands-on approach, participants will bridge the gap between theoretical knowledge and practical application, acquiring specific competencies essential for success in the evolving field of Industry 4.0 production.

5.2. Presentation of the list of activities

Five activities are developed in this course to present practical examples and use cases related to production 4.0. The offered use cases are the following.

- Act U.2.1: Emerging uses of smart technologies for production planning and scheduling
- Act U.2.2: Horizontal and vertical integration & Workflow management
- Act U.2.3: IoT/CPS development, integration, Interoperability, visibility, connectivity
- Act U.2.4: Data-driven inventory management
- Act U.2.5: Digital control systems (DCSs)

5.2.1. Act U.2.1: Emerging uses of smart technologies for production planning and scheduling

The objective of this activity is to show based on a use case how smart technologies enhance production planning and scheduling through advanced algorithms, IoT integration, machine learning, and cloud computing and how real-time data analysis, predictive planning, and intelligent decision-making optimize processes and reduce lead times.
In this activity, three task are delivered labelled as follows:

- Task 1: Description of a real production line: Related Problem and requirements specification.
- Task 2: Classical planning concepts.
- Task 3: Dynamic scheduling: Job shop

The figures 11 presents an excerpt of the slides of this activity. In this case this slide relates to the problems and required specification.

More information may be found at the learning platform at: https://lel.eplus-enhance.eu/course/view.php?id=39

(access credentials are available for EC reviewers)

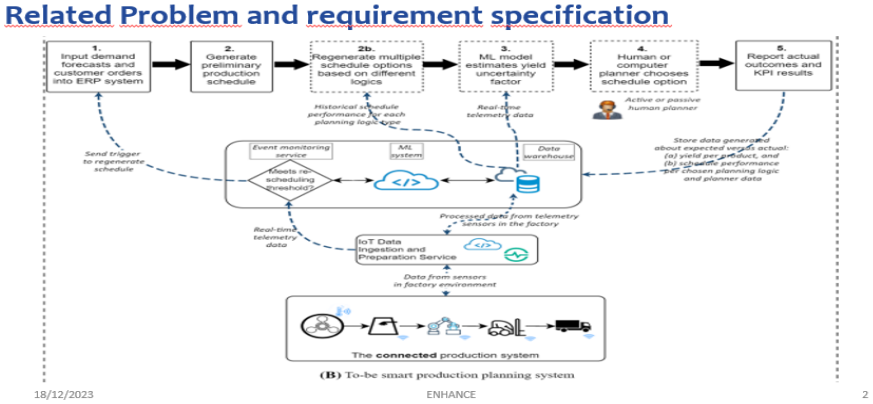

Figure 11. Print screen Act U.2.1: Emerging uses of smart technologies for production planning and scheduling

The content is organized according to the following syllabus:

Enhance	**Learning Activity Syllabus**					Co-funded by the Erasmus+ Programme of the European Union
ENHANCE Domain	Production 4.0					
Skill Set	Production Engineering use cases					
Activity Title	Act U.2.1 Emerging uses of smart technologies for production planning and scheduling					
Activity Acronym	Act_U.2.1					
Activity Description	The objective of this activity is to show based on a use case how smart technologies enhance production planning and scheduling through advanced algorithms, IoT integration, machine learning, and cloud computing and how real-time data analysis, predictive planning, and intelligent decision-making optimize processes and reduce lead times.					
Keywords	Real-time Decision-making	Smart Technologies	Production Optimization			

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 : Description of a real production line: Related Problem and requirements specification	**production systems configuration and charateristics**	presentation	PPT File		2	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	MCQ	Task 1	task 2
Task 2 : Concepts Classiques de la planification	**planification tools according to the system configurations**	presentation	PPT File		3	Problem Solving Critical thinking infographic communication	projet 1 : développement d'un modèle de simulation pour la collecte des données		
Task 3 : Ordonnencment dynamique : Atelier job shop	**Scheduling tools and dynamic scheduling**	presentation	PPT File		4	Problem Solving Critical thinking infographic communication	projet 2 : Développement d'un modèle de pilotage basé sur l'apprentissage automatique		

Meta Skills							
Module Outcomes	Participants will be able to use smart technologies to optimize planning and scheduling process						
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Project report, Project presentation						
Teaching Material							
Equipment							
Multimedia							
Content URL							
Class requirements *(equipement that participants should bring)*	Computer						
Prerequisites *(previous modules that student should attend)*							
Total duration *(Hrs)*	9						

5.2.2. Act U.2.2: Horizontal and vertical integration & Workflow management

This activity is designed to impart essential skills pertaining to Horizontal and Vertical Integration, along with Workflow Management in the Industry 4.0 era. Participants will gain a comprehensive understanding of the seamless coordination between horizontal and vertical processes within modern industrial frameworks. The focus is on fostering expertise in integrating diverse systems and optimizing workflows to enhance operational efficiency. Through a combination of theoretical insights and practical applications, participants will acquire the necessary competencies to navigate and contribute effectively to the interconnected landscape of Industry 4.0. Ultimately, the activity aims to empower individuals with the skills required for successful integration and workflow management in the evolving industrial paradigm.

Four tasks are offered into this activity which are:

- Task 1: Industry 4.0: Connectivity and Integration.
- Task 2: Horizontal and vertical integration.
- Task 3: Levels of vertical integration.

In figure 12, a Print screen of one slide is presented as an example. The content of this slide concerns the connectivity and integration in the context of industry 4.0.

More information may be found at the learning platform at:

https://lel.eplus-enhance.eu/course/view.php?id=41

(access credentials are available for EC reviewers)

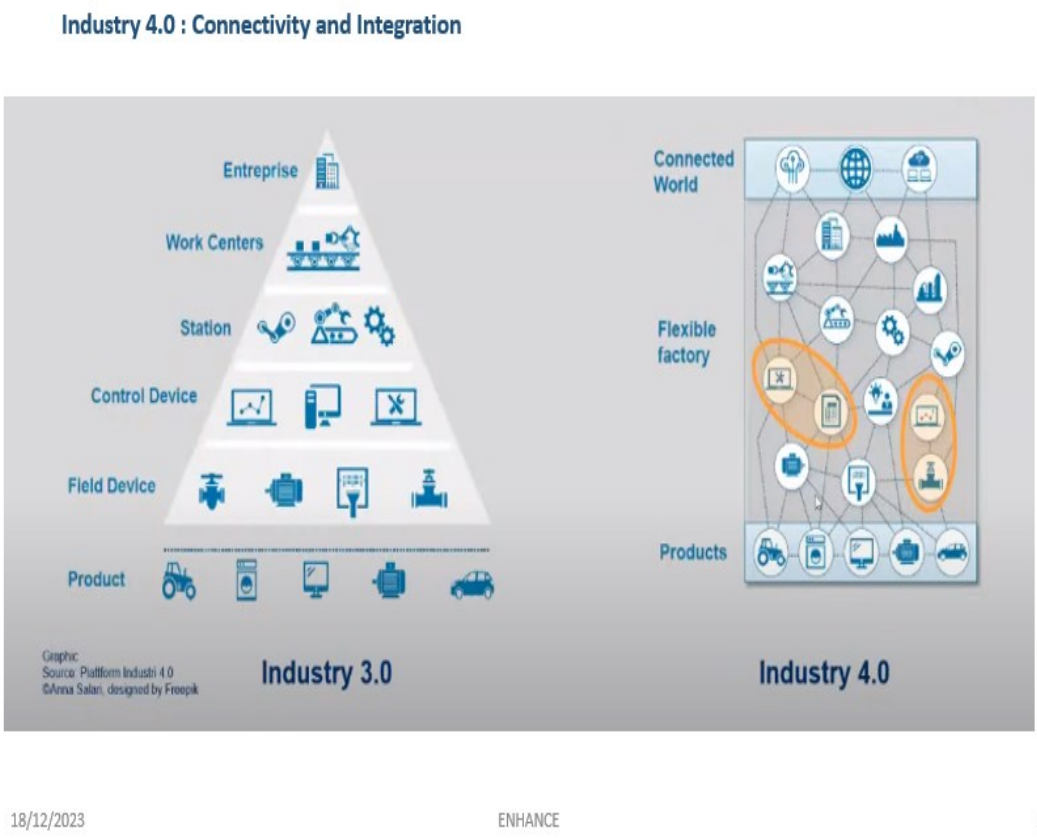

Figure 12. Print screen Act U.2.2: Horizontal and vertical integration & Workflow management

The content is organized according to the following syllabus:

Enhance Readiness - Reduction - Quality	**Learning Activity Syllabus**						Co-funded by the Erasmus+ Programme of the European Union			
ENHANCE Domain	Production									
Skill Set	Production Engineering use cases									
Activity Title	Act_U2.2-IIT Horizontal and vertical integration & Workflow management									
Activity Acronym	Act_U2.2									
Activity Description	This activity is designed to impart essential skills pertaining to Horizontal and Vertical Integration, along with Workflow Management in the Industry 4.0 era. Participants will gain a comprehensive understanding of the seamless coordination between horizontal and vertical processes within modern industrial frameworks. The focus is on fostering expertise in integrating diverse systems and optimizing workflows to enhance operational efficiency. Through a combination of theoretical insights and practical applications, participants will acquire the necessary competencies to navigate and contribute									
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**
Task 1 : Industry 4.0 : Connectivity and Integration	different technologies of industry 4.0; the difference between industry 3.0 and Industry 4,0		presentation		ppt file	2	Problem Solving Critical thinking infographic communication	Project : develop a framework for horizontal and vertical integration		
Task 2 : Horizontal and vertical integration	SCM level from supplier to costumer ; Real time KPIs, flexible configuration of the products, Intelligente factory		presentation		ppt file	2	Problem Solving Critical thinking infographic communication			
Task 3 : Levels of vertical integration	Physical production process; sensors and other actuators; monitoring and control of production processes with PLC ; manufacturing management layer (MES); business management layer (ERP/PLM)		presentation		ppt file	3	Problem Solving Critical thinking infographic communication			
Task 4 : Steps for modelling Cyber-Physical Systems taking into account IoT and Vertical and Horizontal Integration	Controller program modelling ; Programming the IoT platform; Develop the user interface (dashboard) ; Connecting the IoT platform with the controller		presentation		ppt file	3	Problem Solving Critical thinking infographic communication			
Meta Skills										
Module Outcomes	Participants will be able to modelling Cyber-Physical Systems taking into account IoT and Vertical and Horizontal Integration									
Target Group *(students, workers...)*	Master students	SME personnels								
Assessment Method	Project report, Project presentation									
Teaching Material										
Equipment	Learning factory I4,0	Matlab toolbox	Cloud server							
Multimedia	Lecture notes	Role play scene setup								
Content URL	https://www.youtube.com/watch?v=RueheBfgHHs									
Class requirements *(equipement that participants should bring)*	Computer									
Prerequisites *(previous modules that student should attend)*	PLC, Sensors network									
Total duration *(Hrs)*	10									

5.2.3. Act U.2.3: IoT/CPS development, integration, Interoperability, visibility, connectivity

This activity focuses on IoT/CPS development, emphasizing integration, interoperability, visibility, and connectivity aspects. Participants will have hands-on experience dealing with real-world small scenarios, providing practical insights into the design and development of cyber-physical systems. The activity aims to enhance participants' proficiency in navigating the complexities of system integration, ensuring interoperability, and optimizing visibility and connectivity. Through practical engagement, individuals will develop valuable skills applicable to the design challenges within the realm of cyber-physical systems. Ultimately, the activity serves as a practical and immersive learning opportunity for participants to gain expertise in IoT/CPS development.

The content of this activity is organized into one task labelled “Task1: Use cases for industrial scenarios”

The figures 13 is a Print screen of one slide from those developed in this activity. This slide presents an example for system commission and system understanding.

More information may be found at the learning platform at:

https://lel.eplus-enhance.eu/course/view.php?id=26
(access credentials are available for EC reviewers)

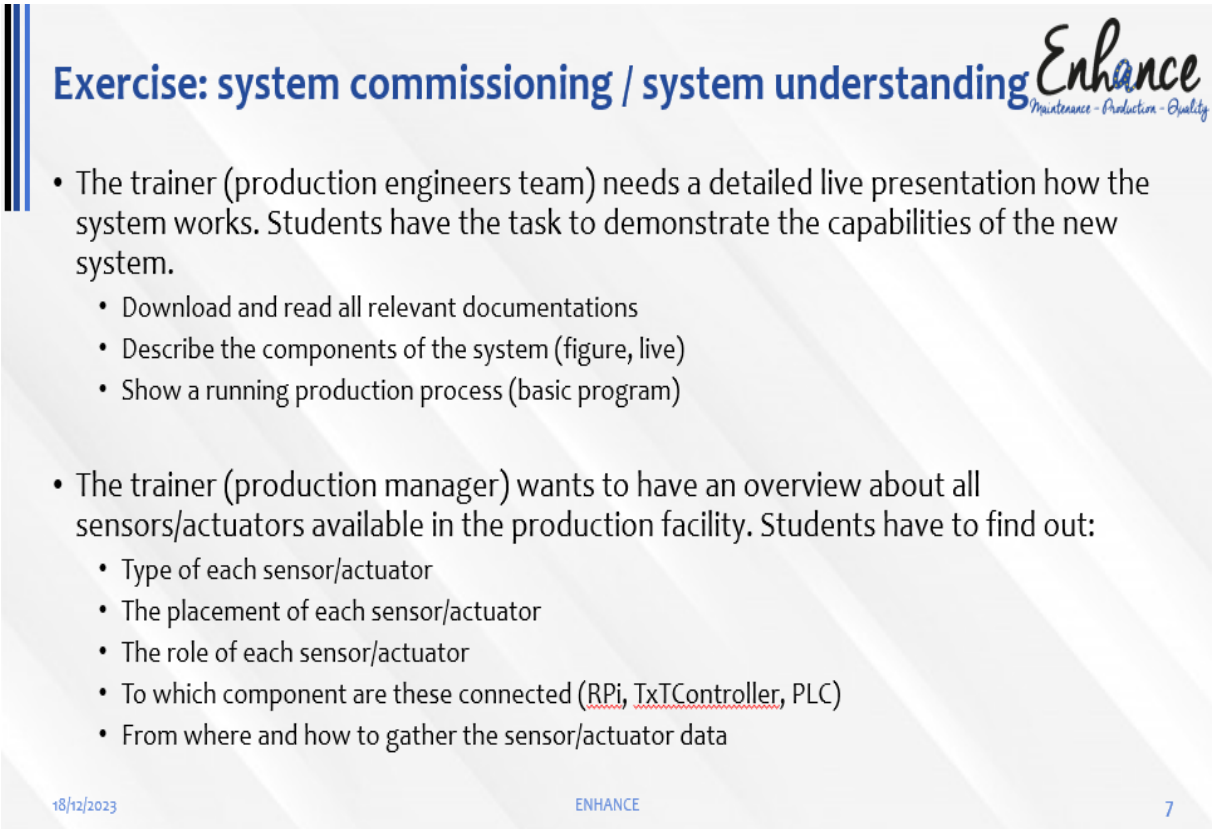

Figure 13. Print screen Act U.2.3: IoT/CPS development, integration, Interoperability, visibility, connectivity

The content is organized according to the following syllabus:

Enhance	**Learning Activity Syllabus**						Co-funded by the Erasmus+ Programme of the European Union
ENHANCE Domain	Production						
Skill Set	Use case						
Activity Title	IoT/CPS development, integration, Interoperability, visibility, connectivity						
Activity Acronym	Act_U.2.3						
Activity Description	This activity focuses on IoT/CPS development, emphasizing integration, interoperability, visibility, and connectivity aspects. Participants will have hands-on experience dealing with real-world small scenarios, providing practical insights into the design and development of cyber-physical systems. The activity aims to enhance participants' proficiency in navigating the complexities of system integration, ensuring interoperability, and optimizing visibility and connectivity. Through practical engagement, individuals will develop valuable skills applicable to the design challenges within the						
Keywords	IIoT	Transparency	Tracebility	Automation	Process Control	Interoperability	

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: Use cases for industrial scenarios	technology selection, Prototyping, integration,		case study	Presentation Discussion	ppt slides, videos,	20	Problem Solving, Team working, co creation, communication,	prototyping	refienement till validation	Done

Meta Skills	Adaptability, Effective storytelling, Authenticity, Creativity, Giving and receiving feedback						
Module Outcomes	Participants will be able to use Industry 4.0 technologies such as IIoT to solve specific problems in industrial environements						
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Project report	Project presentation	Assessment rubric for teamwork	Code review	Demonstration validation		
Teaching Material							
Equipment	DB, IDE., servers/PCs	sensors and accessories, MC and embedded systems, modules for wireless, communication	Learning factory				
Multimedia							
Content URL							
Class requirements *(equipement that participants should bring)*	Laptopos/Notebooks/Desktops						
Prerequisites *(previous modules that student should attend)*	Act 1.2	Act U 2.1	Act 3.3				
Total duration *(Hrs)*	20						

5.2.4. Act U.2.4: Data-driven inventory management

This use-case focuses on data-driven inventory management, aiming to offer practical illustrations that complement the theoretical foundation outlined in the course "Big Data and Predictive Inventory Analytics." It provides participants with hands-on examples, allowing them to apply learned concepts in real-world scenarios. Through this practical application, participants will deepen their understanding of leveraging big data for predictive analytics in inventory management. The objective is to bridge theory and practice, empowering individuals to effectively implement data-driven strategies for optimizing inventory processes. Ultimately, the use-case enriches the course experience by reinforcing theoretical knowledge with practical insights and applications.

Three tasks are offered in order to deliver the content as follows:

- Task 1. Brief Introduction into ML for inventory Management – challenges addressed, typical ML flow.
- Task 2. Scenario 1.
- Task 3. Scenario 2

The figures 14 provide an excerpt of the slides of this activity. In this slide, the objectives of inventory management are explained with details.

More information may be found at the learning platform at:

https://lel.eplus-enhance.eu/course/view.php?id=20
(access credentials are available for EC reviewers)

Figure 14. Print screen Act U.2.4: Data-driven inventory management

The content is organized according to the following syllabus:

Enhance	**Learning Activity Syllabus**										
ENHANCE Domain	Production 4.0										
Skill Set	Ability to apply ML to solve inventory problems										
Activity Title	Data-driven inventory management										
Activity Acronym	Act_U2.4										
Activity Description	This use-case centers on data-driven inventory management, aiming to offer practical illustrations that complement the theoretical foundation outlined in the course "Big Data and Predictive Inventory Analytics." It provides participants with hands-on examples, allowing them to apply learned concepts in real-world scenarios. Through this practical application, participants will deepen their understanding of leveraging big data for predictive analytics in inventory management. The objective is to bridge theory and practice, empowering individuals to effectively implement data-driven strategies for optimizing inventory processes. Ultimately, the use-case enriches the course experience by reinforcing theoretical knowledge with practical insights and applications.										
Keywords	Inventory	BigData	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**
1. Brief Introduction into ML for invnetory Management - challenges adressed, typical ML flow.	Basic Understanding of ML types and categories. Understanding of a "typical" ML flow and problems that are addressed in the scenarios.	Lecture	Group Discussion	ppt file	30min	. Problem Solving . Critical thinking . Presentation . Infographic communication	Question 1	Task 3 (MDIS)	task 2 (SND)
2. Scenario 1	The demand forecasting problem is considered, PySpark as a tool adopted for BigData processing. Ability to apply PySpark for dataset processing.	Lecture, Live Demonstration	Group Discussion, Individual Assistance	ppt file, code snippets, datasets	1h				
3. Scenario 2	The demand forecasting problem is considered. In this case deep learning approach (LSTM) is applied. Ability to apply LSTM for regression type problems.	Lecture, Live Demonstration	Group Discussion, Individual Assistance	ppt file, code snippets, datasets	1h				

Meta Skills							
Module Outcomes	Participants will be able to apply various ML including deep learning for demand forecasting inventory problem.						
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Project report, Project presentation, Live demonstration						
Teaching Material							
Equipment	Google Colab						
Multimedia	Lecture notes	Role play scene setup					
Content URL							
Class requirements *(equipement that participants should bring)*	Computer						
Prerequisites *(previous modules that student should attend)*	Big data and predictive inventory analytics						
Total duration *(Hrs)*	2,5						

5.2.5. Act U.2.5: Digital control systems (DCSs)

This activity's goal is to furnish a practical example for implementing a distributed control system through multi-agent simulation. Participants will engage in hands-on exercises to apply theoretical knowledge in a real-world context, gaining proficiency in the implementation of distributed control systems. The objective is to bridge theory and practice, allowing participants to develop practical skills in utilizing multi-agent simulation for effective system control. Through this immersive experience, individuals will enhance their understanding of distributed control system dynamics and their application in diverse scenarios. Ultimately, the activity empowers participants to implement robust and efficient control systems in practical settings.
All the content of this activity is offered into one task related to the implementation of a distributed control system using multiagent simulation

Figure 15 illustrates an example of the developed slides in this activity. The content of this slide concerns the modelling and simulation modelling.

More information may be found at the learning platform at:

https://lel.eplus-enhance.eu/course/view.php?id=37
(access credentials are available for EC reviewers)

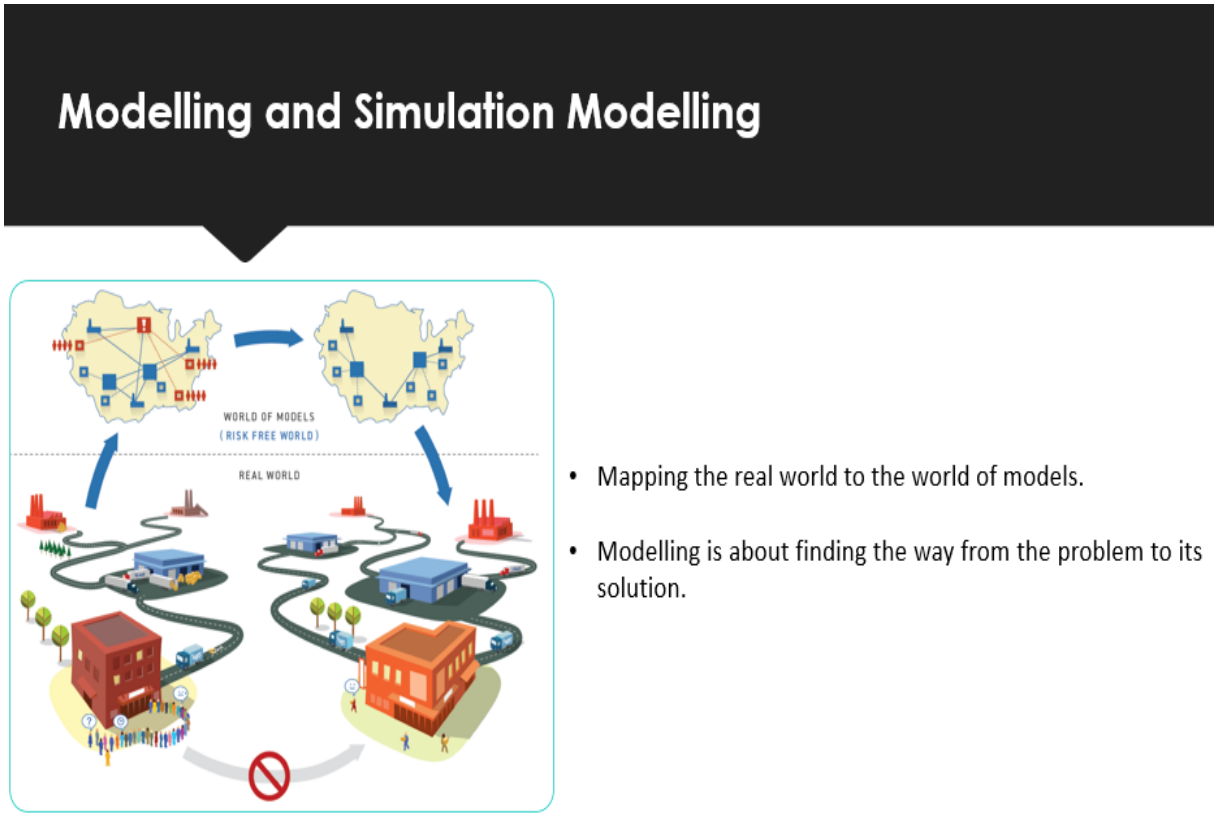

Figure 15. Print screen Act U.2.5: Digital control systems (DCSs)

The content is organized according to the following syllabus:

Enhance	**Learning Activity Syllabus**									
ENHANCE Domain	Production 4.0									
Skill Set	Advanced Produtction strategies									
Activity Title	Digital control systems (DCSs)									
Activity Acronym	Act_U.2.5									
Activity Description	This activity's goal is to furnish a practical example for implementing a distributed control system through multi-agent simulation. Participants will engage in hands-on exercises to apply theoretical knowledge in a real-world context, gaining proficiency in the implementation of distributed control systems. The objective is to bridge theory and practice, allowing participants to develop practical skills in utilizing multi-agent simulation for effective system control. Through this immersive experience, individuals will enhance their understanding of distributed control system dynamics and their application in									
Keywords	Multi agent simulation									

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	implement a distributed control system using multi-agent simulation		simulation		video	4	.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	Quizz	repeat until done	done

Meta Skills							
Module Outcomes	Participants will be able to simulate a basic digital control system						
Target Group *(students, workers...)*	Master students	SME personnels					
Assessment Method	Quizz						
Teaching Material							
Equipment							
Multimedia	Videos						
Content URL							
Class requirements *(equipement that participants should bring)*	Laptop/Desktop	Anylogic Simulation software					
Prerequisites *(previous modules that student should attend)*							
Total duration *(Hrs)*	4						

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Conclusion

The creation of this deliverable was a collaborative effort that involved a systematic process to ensure its quality and relevance. The content was developed through a series of structured steps, beginning with the identification of key topics and learning objectives for each section. Subject matter experts, educators, and industry professionals were consulted to ensure that the courses covered in the first two sections—Production, Planning, Scheduling, and Control in Industry 4.0, and Factory 4.0: Concepts, Techniques, and Applications—aligned with current industry trends and educational standards.

Additionally, the use case section was developed by drawing on real-world examples and practical scenarios. This involved researching and selecting relevant cases that exemplify the application of production in Industry 4.0 principles. The inclusion of practical examples not only grounded the theoretical concepts but also aimed to resonate with the experiences and challenges faced by professionals in the field.

Each component within this compilation is accompanied by a concise objective, illustrative screens, a direct link on the public platform, and a detailed syllabus.

Looking ahead, this deliverable is intended to be a valuable resource for the students and industrials. It is envisioned that the content will be integrated into the curriculum of relevant courses, providing students with a foundational understanding of Industry 4.0 concepts and their practical implications. The deliverable is designed to empower students to bridge the gap between theoretical knowledge and real-world applications related to production, preparing them for the challenges and opportunities presented by the evolving industrial landscape.