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Capacity Building in the field of Higher Education

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

D3.3 Quality Audit Reports

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1.0		Initial Version	Nejib Moalla
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Executive Summary

The quality audit reports follow a quality audit methodology based on the ISO 9001 improvement principles to assess: the quality of the training activities with academic staff and industrial representatives, the quality of the adaptation or extension process of the partners countries' 8 programmes and related courses, and the quality of the effective consumption of the purchased equipment for the 4 PC institutions. This deliverable provides an action plan to improve the quality of the training project after the end of the ENHANCE project.

Table of contents

Table of Figures

Table of Tables

1. Introduction

This document is developed as part of the ENHANCE project to report on the quality of conducted training sessions with academic trainers, industrial representatives, specific sessions with students, and administrative staff. The performed quality audit covers the consumption of the proposed training activities to extend or adapt the existing training courses as developed within the 8 education programmes in the four PC. The justification of the consumption of the purchased equipment is highlighted in this deliverable.

1.1. Purpose of the document

This document reports the quality audit related to the training sessions performed with trainers, industrial representatives, and students.

1.2. Reference documents

Detailed statistics on the conducted training sessions are developed in deliverable D2.6.

1.3. Applicability

This document will be used by the different partner countries' institutions to assess the quality of the training sessions. It will help to confirm the relevance of the training activities and their acceptance by the different stakeholders.

1.4. Definitions

NA

1.5. Structure of the document

The document is structured in eight sections:

- Section 1: introduction
- Section 2: ENHANCE project overview
- Section 3: Quality audit methodology
- Section 4: Training quality audit
- Section 5: Quality audit of the adaption / extension process
- Section 6: Quality audit of the effective equipment consumption
- Section 7: Action plan to improve the training activities content
- Section 8: Conclusion

1.6. List of acronyms

DIH: Digital Innovation Hub
HEI: Higher Education Institute
LF: Learning Framework
MPQ 4.0: Maintenance 4.0, Production 4.0, and Quality 4.0
PC: Partner Countries (HEI in Tunisia and Morocco)
PDCA: Plan Do Check Act

2. ENHANCE project overview.

ENHANCE – strENgtHening skills and training expertise for TunisiAN and MoroccCan 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.
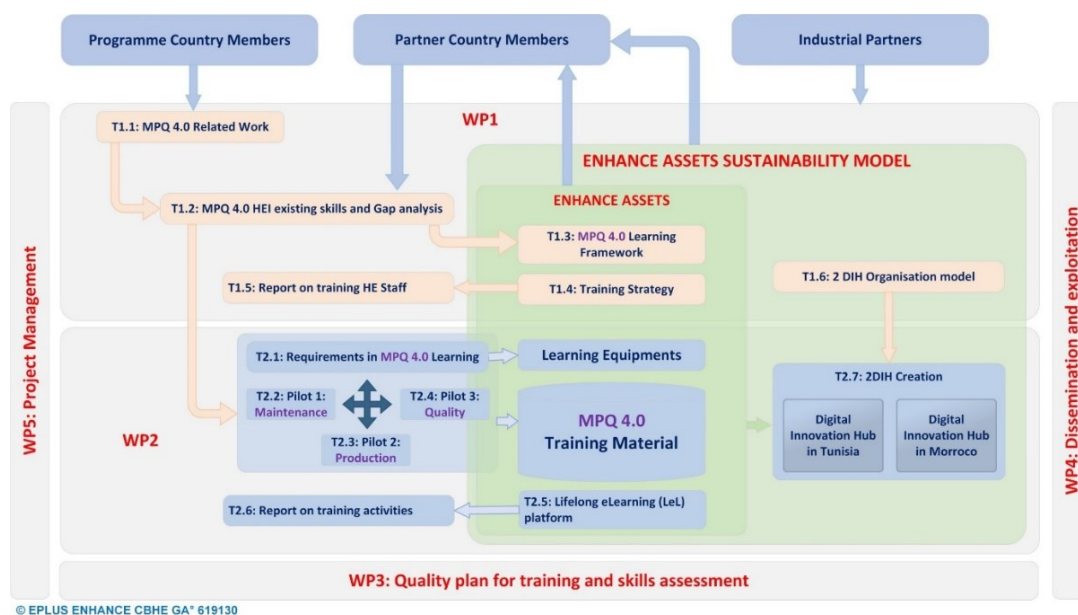
Figure 1. ENHANCE project organization.

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. Quality audit methodology

The proposed training activities were prepared and justified through the different WP1 tasks. The set of the 42 activities is selected and developed:
- To significantly impact the eight training programmes in the four partner countries' institutions
- As answers to the expectations of industrial companies in partners countries as collected through dedicated surveys
- To support trainers in the four partners in the acquisitions of industry 4.0 concepts and applications in the MPQ 4.0 topics through the train the trainers' sessions.
- To train industrial representatives
- To train students
- To support the training services to be proposed by the targeted competence centres and the DIHs.

The activities development lifecycle is presented in Figure 2.
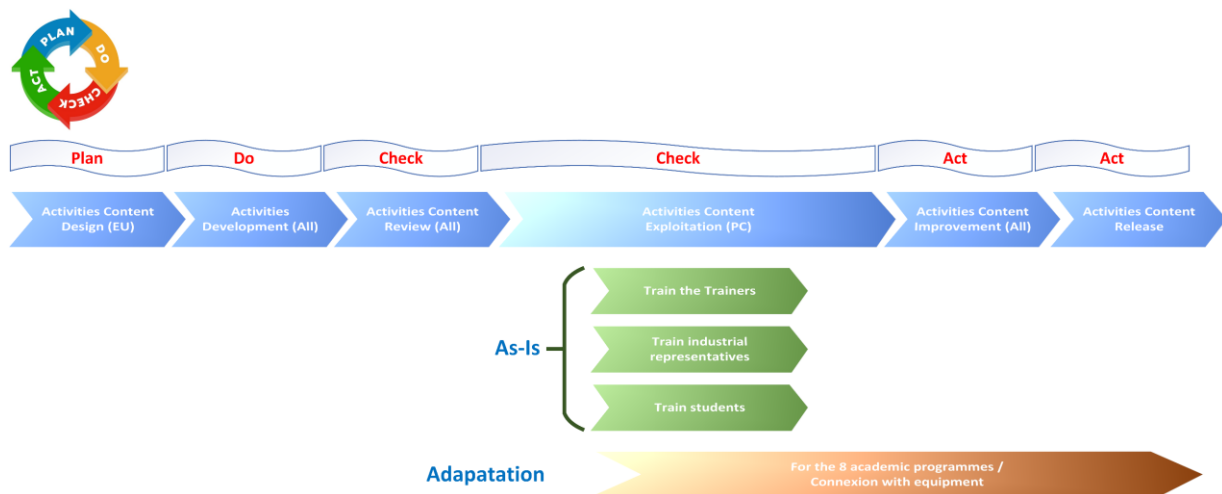
Figure 2: Training activities lifecycle

The training activities development process follows the seven ISO 9001[1] improvement principles.

1. Engagement of people
All the project partners are engaged in the development of all the project tasks and related deliverables. This approach helps to empower all the project resources with additional skills related to MPQ 4.0 processes, technological skills, and project management skills.

2. Trainees focus
The ENHANCE project main customers are the partner countries institutions. Their participation in a capacity building project is motivated by their needs to:
- Improve the content of their industrial engineering programmes by integrating the most recent and well-integrated concepts related to industry 4.0.

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[1] https://www.iso.org/standard/62085.html

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- Engage the higher Education trainers in an upskilling process for the acquisition of new industry 4.0 concepts.
- Invite industrial representatives to on-demand training sessions to showcase the new skills of their students.

3. Leadership
The management board of the ENHANCE project shares the same vision about the project priorities, quality assurance objectives, the principles related to the lifecycle management of training activities, etc. Each local coordinator supports local researchers to meet efficiently the quality objectives of project and the alignment of the project strategic goals with their internal activities.

4. Process approach
The Plan Do Check Act (PDCA) principle of the ISO 9001 Standard is adopted to manage the lifecycle of the training activities development. It helps to concentrate efforts in the improvement of proposed training materials, smoother cross-collaboration between partners to collect and integrate their contributions and ensure the consistency of the final deliverables according to the predefined objectives.

5. Continual Improvement
The organisation of the training sessions with trainers, industrials representatives, and students allows to collect feedback about the objectives of the activities, their exploitation capabilities, and the potential to sustain the proposed content for future exploitation. This feedback will be considered in the improvement of all the training activities.

6. Evidence-based decision making
The decision to deeply revise the training activities content can be reached if several factual feedback highlighting the difficulty to understand or to reuse the proposed content. This factual approach helps to guarantee the capacity building objective behind the ENHANCE project.

7. Relationship management
The interaction between the ENHANCE team and all the other stakeholders contributing or using the proposed training activities is based on predefined communication channels and messages helping to harmonise the message to deliver in coherence with the project goals and objectives. For example, the selection of the covered topics in the definition of the training activities is mainly generated from the initial gap analysis performed in the task / deliverable 1.2. If the training activities consumers are expecting more or different content, they can find in the first deliverable D1.1 an exhaustive related work about the concepts of MPQ 4.0.

The acquisition of the skills related to the developed ISO 9001 concepts and their application for training development purpose was performed during a dedicated certification programme (Quality Manager) conducted by the AFNOR International Group for permanent representatives in the four PC institutions.

The PDCA cycle was applied to support this training activities development. This cycle enables an organization to ensure that its processes are adequately resourced and managed, and that opportunities for improvement are determined and acted on.

The quality audit process was proposed at different levels:
- At the **training level** to assess the feedback of trainers and industrial representatives. The section 4 is dedicated to this audit with dedicated assessment templates.

- At the **adoption level** to assess the consumption of the proposed activities in the eight selected academic programmes. The section 6 is dedicated to this audit.
- At the **exploitation level** to assess, for each partner country, the mapping between selected activities and the set of purchased equipment.

4. Training Quality Audit related to the learning programmes and seminars.

This first quality audit is proposed to assess the perception of the different trained actors (trainers and industrial representatives) regarding the proposed training activities in the different sessions. Two important aspects are selected: one related to the consumption level of the 42 training activities during the different training sessions; and another related to the feedback received from the participants using a predefined evaluation form.

4.1. Quality audit for train the trainers sessions.

The proposed training evaluation template is proposed in Figure 3. The evaluation form is composed by 10 questions and organised in 3 sections:
- Direction: assess the scope of the activity, its objectives, the connection with existing teaching modules in the local programme, etc.
- Exploitation: assess if the activity is ready to be used by the trainers
- Sustainability: assess if the activity is useful for other trainees

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Activity Evaluation Form

Name of the activity   :_____

Date of the training   :_____

Partner name   :_____

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

To what extent the scope of the activity was clear?

Comment:_____   1 2 3 4 5

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

Comment:_____   1 2 3 4 5

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

Comment:_____   1 2 3 4 5

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

Comment:_____   1 2 3 4 5

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

Name of courses	:_____
	:_____
	:_____

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

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

Comment:_____   1 2 3 4 5

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To what extent additional adaptation efforts are needed to reuse the proposed activity contents?

Comment:_____   1 2 3 4 5

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

Comment:_____   1 2 3 4 5

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

To what extent you consider the activity content is useful for other trainers training for the next three years?

Comment:_____   1 2 3 4 5

To what extent you consider the activity content is useful for students training for the next three years?

Comment:_____   1 2 3 4 5

To what extent you consider the activity content is useful for industrial workers training for the next three years?

Comment:_____   1 2 3 4 5

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

Activity Evaluation Form   *p. 2*

Figure 3: Activity evaluation form

The proposed four training sessions are detailed below.

Session 1:
Partner Country Institution: International Institute of Technology (IIT, Sfax – Tunisia)
Dates: from 16/05/2022 to 27/05/2022
Total number of trained trainers: 17
Gender balance: 5 Males and 12 Females
Details about the presented activities and the participation of trainers in Table 1:

Table 1: Train the trainers schedule in IIT

Date	Domain	ENHANCE Training Activities	Nr. Internal Trainers	Nr. External Trainers
16/05/2022 - M	Quality 4.0	Act U3.1 Sensors sensitivity analysis and selection	4	1
16/05/2022 - A	Production 4.0	Act U.2.5 Digital control systems (DCSs)	3	2
17/05/2022 - M	Quality 4.0	Act 5.2 Non-Conformities RCA and Quality gates design	4	1
17/05/2022 - A	Production 4.0	Act 4.4 KPI, Dashboarding and data visualisation	4	3
18/05/2022 - M	Production 4.0	Act 4.2 VSM for production 4.0	2	6
18/05/2022 - A	Production 4.0	Act 3.1 Design and development of smart Production Planning/Scheduling systems	2	4
19/05/2022 - M	Production 4.0	Act 3.2 Planning and scheduling techniques and approaches in industry 4.0	2	3
19/05/2022 - A	Maintenance 4.0	Act 2.5 Industry 4.0 Asset & Maintenance Management Systems	2	0
20/05/2022 - M	Production 4.0	Act U.2.2 Horizontal and vertical integration & Workflow management	2	7
20/05/2022 - A	Quality 4.0	Act 5.3 QC model design	2	7
23/05/2022 - M	Quality 4.0	Act U.3.3 IoT and BPM for Integrated VSM	3	5
23/05/2022 - A	Maintenance 4.0	Act 2.4 Downtime forecast and optimal maintenance planning	2	2
24/05/2022 - M	Production 4.0	Act 3.5 Big data and predictive inventory analytics	2	2
24/05/2022 - A	Maintenance 4.0	Act 2.2 Maintenance planning and scheduling	2	2
25/05/2022	MPQ 4.0	**Industry 4.0 Workshop**	-	-

Date	Domain	ENHANCE Training Activities	Nr. Internal Trainers	Nr. External Trainers
26/05/2022 - M	Maintenance 4.0	Act 1.3 Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 context	4	2
26/05/2022 - A	Maintenance 4.0	Act U.1.3 ML and application for maintenance	4	2
27/05/2022 - M	Production 4.0	Act U.2.3 CPS design and development	2	1
27/05/2022 - A	Production 4.0	Act 3.4 Data-driven planning/scheduling models and algorithms	2	1

The analysis of the trainers' feedback is summarized in the following Boxplot diagram (Figure 4). The average evaluation of all the presented activities was higher than 4.

Figure 4: Activities evaluation results from the Trainers in the IIT session

Session 2:
Partner Country Institution: University Ibn Tofaïl (ENSAK, Kenitra – Morocco)
Dates: from 18/07/2022 to 29/07/2022
Total number of trained trainers: 19
Gender balance: 8 Males and 11 Females
Details about the presented activities and the participation of trainers in Table 2:

Table 2: Train the trainers schedule in UIT

Date	Domain	ENHANCE Training Activities	Nr. Internal Trainers	Nr. External Trainers
18/07/2022 - M	Maintenance 4.0	Act 1.4 Contributions of Smart Maintenance 4.0 to Energy Management & Energy Efficiency of Industry 4.0 Assets	7	1

Date	Domain	ENHANCE Training Activities	Nr. Internal Trainers	Nr. External Trainers
18/07/2022 - A	Quality 4.0	Act 5.5 IoT and BPM for Integrated VSM	7	1
19/07/2022 - M	Production 4.0	Act 4.2 VSM for production 4.0	9	2
19/07/2022 - A	Production 4.0	Act 4.4 KPI, Dashboarding and data visualisation	9	3
20/07/2022 - M	Maintenance 4.0	Act 2.2 Maintenance planning and scheduling	7	2
20/07/2022 - A	Maintenance 4.0	Act U.1.3 ML and application for maintenance	7	1
21/07/2022 - M	Quality 4.0	Act U.3.1 Sensors sensitivity analysis and selection	7	3
21/07/2022 - A	Production 4.0	Act 4.1 PLM and Digital Factory	6	3
22/07/2022 - M	Quality 4.0	Act 5.2 Non-Conformities RCA and Quality gates design	6	3
22/07/2022 - A	Production 4.0	Act 3.2 Planning and scheduling techniques and approaches in industry 4.0	5	1
25/07/2022 - M	Quality 4.0	Act 5.3 QC model design	8	1
25/07/2022 - A	Production 4.0	Act 3.3 Methods and frameworks for control systems in agile manufacturing	9	1
26/07/2022 - M	Quality 4.0	Act 6.4 Prescriptive and adaptive decision for Quality Control	6	0
26/07/2022 - A	Production 4.0	Act U.2.3 CPS design and development	6	0
27/07/2022 - M	Maintenance 4.0	Act 1.2 Sensor Network Design in Smart Maintenance 4.0 contexts	5	1
27/07/2022 - A	Maintenance 4.0	Act 2.4 Downtime forecast and optimal maintenance planning	6	0
28/07/2022 - M	Production 4.0	The usage of a zComponent from the ZDMP project (Data Acquisition, Message Bus, Monitoring and Alerting, …).	4	1
28/07/2022 - A	Production 4.0	The usage of a zComponent from the ZDMP project (Data Acquisition, Message Bus, Monitoring and Alerting, …).	5	0
29/07/2022 - M	Production 4.0	Act U.2.1 Emerging uses of smart technologies for production planning and scheduling	7	2
29/07/2022 - A	Production 4.0	Act 4.3 Virtual Reality for simulation	6	0

The analysis of the trainers' feedback is summarized in the following Boxplot diagram (Figure 5). The average evaluation of all the presented activities was higher than 4,25.
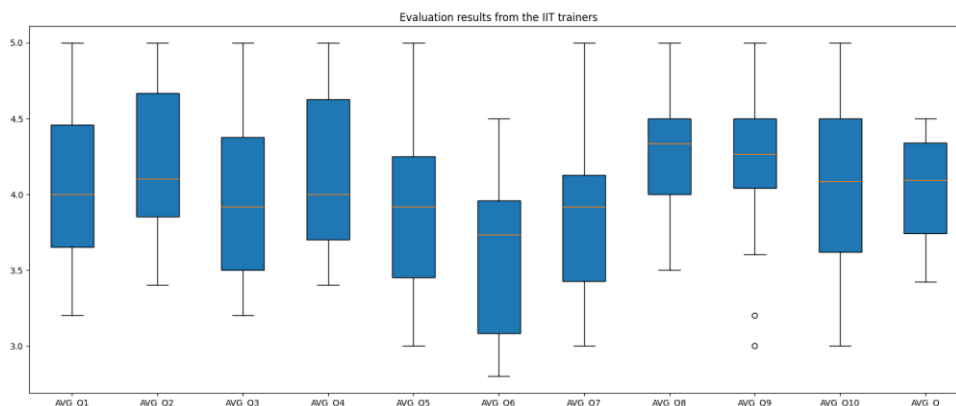

Figure 5: Activities evaluation results from the Trainers in the UIT session

Session 3:
Partner Country Institution: University of Carthage (INSAT, Tunis and FSEGN, Nabeul – Tunisia)
Dates: from 12/12/2022 to 23/12/2022
Total number of trained trainers: 24
Gender balance: 10 Males and 14 Females
Details about the presented activities and the participation of trainers in the following table (Table 3):

Table 3: Train the trainers schedule in UCAR

Date	Domain	ENHANCE Training Activities	Nr. Internal Trainers	Nr. External Trainers
12/12/2022 - M	Maintenance 4.0	Act 2.5 Industry 4.0 Asset & Maintenance Management Systems	10	0
12/12/2022 - A	Maintenance 4.0	Act U.1.3 ML and application for maintenance	9	0
13/12/2022 - M	Production 4.0	Act U.2.5 Digital control systems (DCSs)	9	0
13/12/2022 - A	Production 4.0	Act U.2.4 Data-driven inventory management	4	0
14/12/2022 - M	Maintenance 4.0	Act 1.2 Sensor Network Design in Smart Maintenance 4.0 contexts	9	0
14/12/2022 - A	Maintenance 4.0	Act U.1.2 Data acquisition and storage in industry 4.0	9	0
15/12/2022 - M	Maintenance 4.0	Act 2.2 Maintenance planning and scheduling	8	0

Date	Domain	ENHANCE Training Activities	Nr. Internal Trainers	Nr. External Trainers
15/12/2022 - A	Production 4.0	Act 3.2 Planning and scheduling techniques and approaches in industry 4.0	8	0
16/12/2022 - M	Production 4.0	Act 3.5 Big data and predictive inventory analytics	5	0
16/12/2022 - A	Maintenance 4.0	Act 1.4 Contributions of Smart Maintenance 4.0 to Energy Management & Energy Efficiency of Industry 4.0 Assets	5	0
19/12/2022 - D	MPQ 4.0	Erasmus+ workshop	-	-
20/12/2022 - M	Quality 4.0	Act 5.2 Non-Conformities RCA and Quality gates design	8	0
20/12/2022 - A	Quality 4.0	Act U.3.2 Non-Conformities RCA and Quality gates design	6	0
21/12/2022 - M	Production 4.0	Act 4.4 KPI, Dashboarding and data visualisation	13	1
21/12/2022 - A	Production 4.0	Act 4.2 VSM for production 4.0	13	1
22/12/2022 - M	Quality 4.0	Act U.3.3 IoT and BPM for Integrated VSM	8	0
22/12/2022 - A	Quality 4.0	Act 6.3 Inspection Methods, sampling, Inspection Plan	5	0
23/12/2022 - M	Maintenance 4.0	Act 2.3 Contributions of Industry 4.0 technologies to Total Productive Maintenance	5	0

The analysis of the trainers' feedback is summarized in the following Boxplot diagram (Figure 6). The average evaluation of all the presented activities was higher than 4.
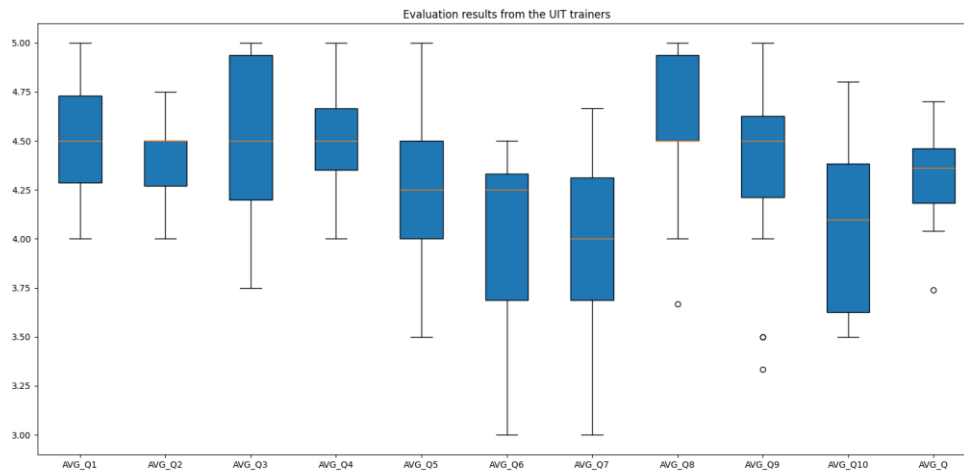

Figure 6: Activities evaluation results from the Trainers in the UIT session

Session 4:
Partner Country Institution: Ecole Centrale Casablanca (ECC, Casablanca – Morocco)
Dates: from 06/03/2023 to 16/03/2023
Total number of trained trainers: 15
Gender balance: 7 Males and 8 Females
Details about the presented activities and the participation of trainers in the following table (Table 4):

Table 4: Train the trainers schedule in ECC

Date	Domain	ENHANCE Training Activities	Nr. Internal Trainers	Nr. External Trainers
06/03/2023 - M	Production 4.0	Act 3.1: Design and development of smart Production Planning/Scheduling systems	8	0
06/03/2023 - A	Maintenance 4.0	Act 1.1 Use cases of eXtended Reality (XR) in Smart Maintenance 4.0 contexts	6	0
07/03/2023 - M	Maintenance 4.0	Act U.1.3 ML and applications for maintenance	4	0
07/03/2023 - A	Maintenance 4.0	Act 1.5 Sustainability Driven Smart Maintenance 4.0	2	0
08/03/2023 - M	Maintenance 4.0	Act 2.2: Maintenance planning and scheduling	6	0
08/03/2023 - A	Maintenance 4.0	Act U.1.2 Data acquisition and storage in industry 4.0	3	0
09/03/2023 - M	Maintenance 4.0	Act 1.3 Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 context	4	2
09/03/2023 - A	Production 4.0	Act U.2.1 Emerging uses of smart technologies for production planning and scheduling	2	2
10/03/2023 - M	Quality 4.0	Act 6.1: Integrated process improvement Act 5.5: VSM for production 4.0	4	1
13/03/2023 - M	Maintenance 4.0	Act 1.2 Sensor Network Design in Smart Maintenance 4.0 contexts	4	0
13/03/2023 - A	Maintenance 4.0	Act U.1.1 Real-time communication	4	0
14/03/2023 - M	Maintenance 4.0	Act 2.4 Downtime forecast and optimal maintenance planning	2	0
14/03/2023 - A	Maintenance 4.0	Act U.1.4 KPI, Dashboarding and data visualisation	4	0
15/03/2023 - M	Production 4.0	Act 3.5: Big data and predictive inventory analytics	2	0

Date	Domain	ENHANCE Training Activities	Nr. Internal Trainers	Nr. External Trainers
15/03/2023 - A	Production 4.0	Act U.2.4 Data-driven inventory management	1	0
16/03/2023 - M	Quality 4.0	Act 6.4: Prescriptive and adaptive decision for Quality Control	4	0
16/03/2023 - A	Quality 4.0	Act U.3.5 Prescriptive and adaptive decision for Quality Control	4	0

The analysis of the trainers' feedback is summarized in the following Boxplot diagram (Figure 7). The average evaluation of all the presented activities was higher than 3.7.
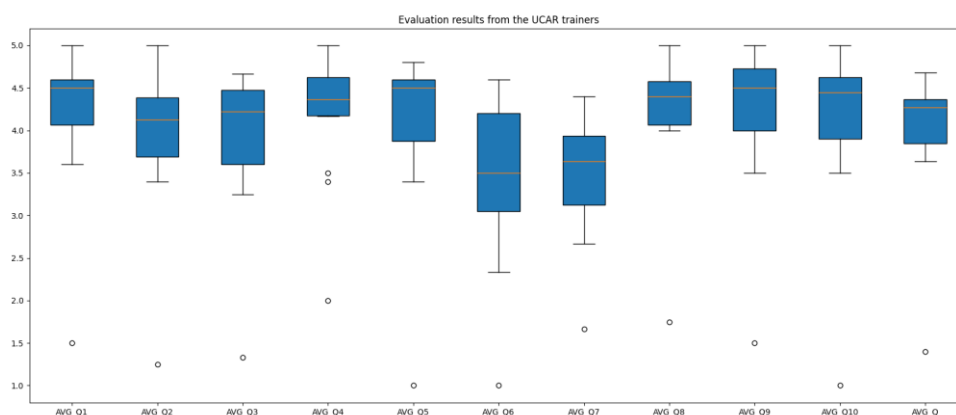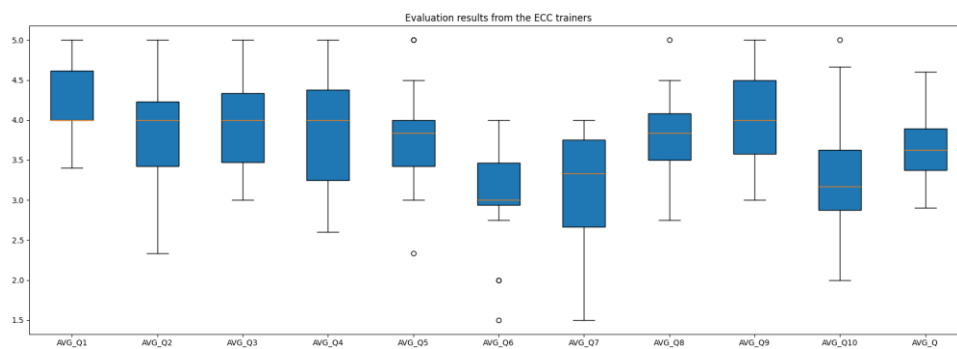

Figure 7: Activities evaluation results from the Trainers in the UIT session

The analysis of all trainers' feedback for the activity "Act 2.2: Maintenance planning and scheduling" is presented in Figure 8.
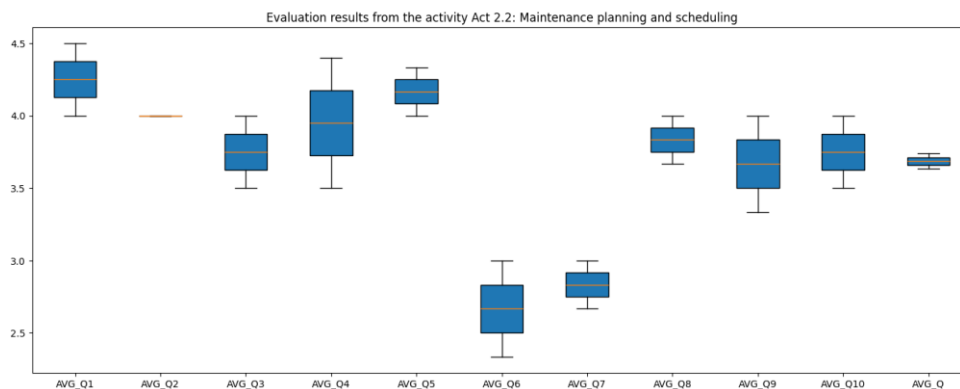
Figure 8: Act 2.2: Maintenance planning and scheduling

The analysis of all trainers' feedback for the activity "Act 4.2: VSM for production 4.0" is presented in Figure 9.

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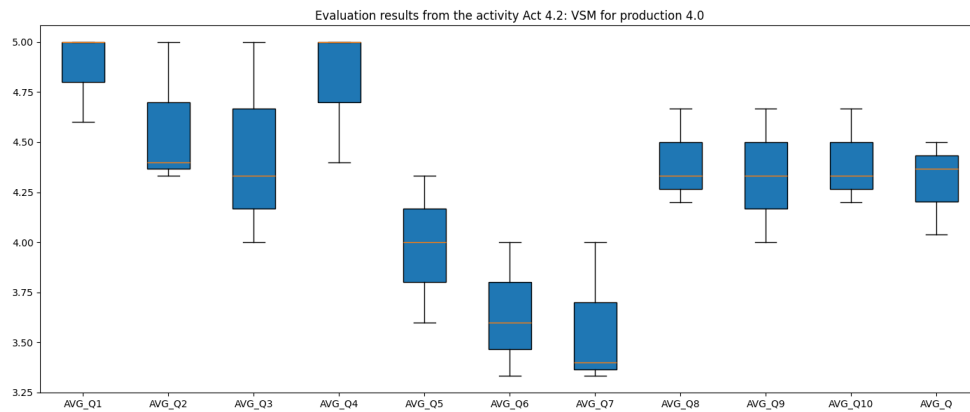
Figure 9: Act 4.2: VSM for production 4.0

The analysis of all trainers' feedback for the activity "Act 5.2: Non-Conformities RCA and Quality gates design" is presented in Figure 10.
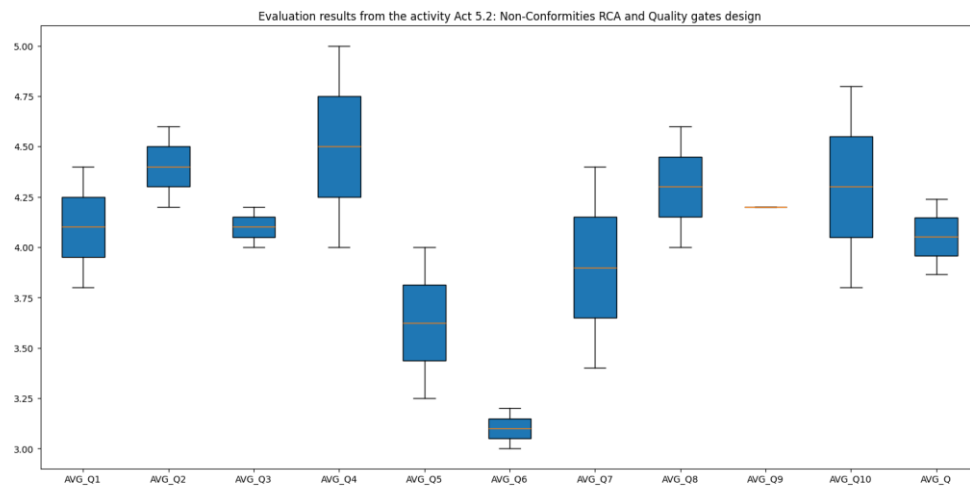
Figure 10: Act 5.2: Non-Conformities RCA and Quality gates design

4.2. Quality audit for train the industrial representatives' sessions.

The proposed training evaluation template is proposed in the following figure (Figure 11). The evaluation form for the industrial session is composed by 10 questions and organised in 3 sections:

- Direction: assess the scope of the activity, its objectives, the connection with existing industrial requirements, etc.
- Exploitation: assess if the activity is ready to be used to train workers in the company.
- Sustainability: assess if the activity is useful for other workers in the company.

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Industrial Session Evaluation Form

Name of the activity :_____

Date of the training :_____

Your Company Name :_____

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

To what extent the scope of the training activity was clear?

Comment:_____ **1 2 3 4 5**

To what extent did the training activity can contribute to improve existing initiatives in your company or in industry in general?

Comment:_____ **1 2 3 4 5**

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

Comment:_____ **1 2 3 4 5**

To what extent did the training activity contain significant current practical content related to Industry 4.0?

Comment:_____ **1 2 3 4 5**

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

To what extent you can reuse the proposed content in your company?

Comment:_____ **1 2 3 4 5**

To what extent additional training efforts are needed to reuse the proposed training activity contents?

Comment:_____ **1 2 3 4 5**

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

Comment:_____ **1 2 3 4 5**

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

To what extent you consider the activity content can be reproduced as a training session in your company?

Comment:_____   **1 2 3 4 5**

To what extent you consider the activity content is useful for other workers in your company?

Comment:_____   **1 2 3 4 5**

To what extent you consider the detailed concepts and applications can be adapted to similar industrial problems in your company?

Comment:_____   **1 2 3 4 5**

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

Signature of the participant
-

Figure 11: Industrial session evaluation form

The four training sessions are detailed below:

Session 1:
Partner Country Institution: Ecole Centrale Casablanca (ECC, Casablanca – Morocco)
Dates: from 08/05/2023 to 12/05/2023
Total number of trained industrial representatives: 42
Gender balance: 30 Males and 12 Females
Details about the presented activities and the participation of industrial representatives as detailed in the following table (Table 5):

Table 5: Train industrial representatives schedule in ECC

Date	Domain	ENHANCE Training Activities	Nr. Industrial representatives
08/05/2023 - A	Production 4.0	Act 3.1: Design and development of smart Production Planning/Scheduling systems	8 (5F/3M)
10/05/2023 - A	Quality 4.0	Act 5.2 Non-Conformities RCA and Quality gates design Act U.3.2 Non-Conformities RCA and Quality gates design	16 (2F/14M)
12/05/2023 - M	Production 4.0 Maintenance 4.0	Act 3.5 Big data and predictive inventory analytics Act U.1.2 Data acquisition and storage in industry 4.0	3 (3M)
12/05/2023 - M	Maintenance 4.0	Act 1.3 Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 context Act U.1.3 ML and application for maintenance	15 (5F/10M)
12/05/2023 - M	Maintenance 4.0 Production 4.0	Act 1.2 Sensor Network Design in Smart Maintenance 4.0 contexts Act U.2.3 CPS design and development	0

The analysis of the industrial representatives' feedback is summarized in the following Boxplot diagram (Figure 12). The average evaluation of all the presented activities was higher than 4.
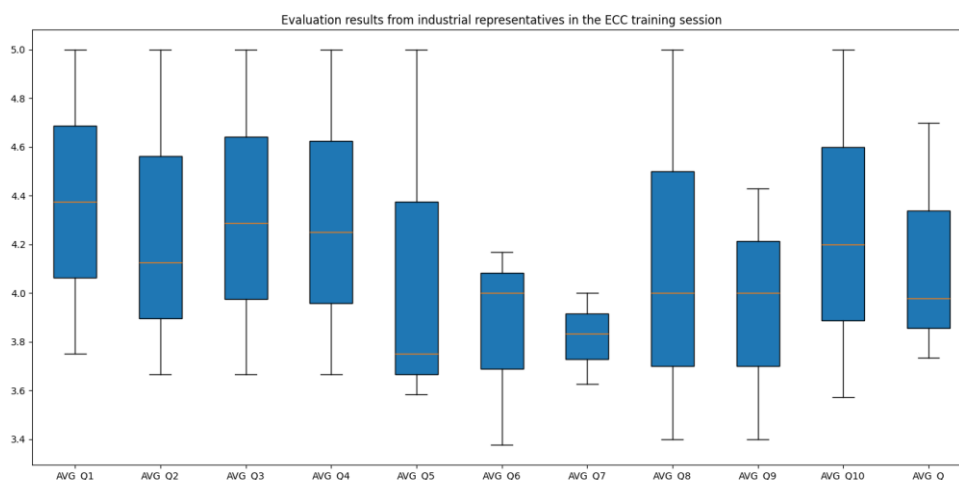
Figure 12: Evaluation results from industrial representatives in the ECC training session

Session 2:
Partner Country Institution: University Ibn Tofaïl (ENSAK, Kenitra – Morocco)
Dates: from 15/05/2023 to 19/05/2023
Total number of trained industrial representatives: 77
Gender balance: 61 Males and 17 Females
Details about the presented activities and the participation of industrial representatives as detailed in the following table (Table 6):

Table 6: Train industrial representatives schedule in UIT

Date	Domain	ENHANCE Training Activities	Nr. Industrial representatives
16/05/2023 - M	Production 4.0	Act 4.2 VSM for production 4.0	39 (9F/30M)
16/05/2023 - M	Maintenance 4.0 Production 4.0	Act 1.2 Sensor Network Design in Smart Maintenance 4.0 contexts Act U.2.3 CPS design and development	40 (9F/31M)
16/05/2023 - A	Production 4.0	Act 3.5 Big data and predictive inventory analytics	27 (7F/20M)
17/05/2023 - M	Quality 4.0	Act 5.2 Non-Conformities RCA and Quality gates design	35 (7F/28M)
17/05/2023 - M	Maintenance 4.0	Act 1.3 Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 context Act U.1.3 ML and application for maintenance	34 (7F/27M)
17/05/2023 - A	Maintenance 4.0	Act 2.3 Contributions of Industry 4.0 technologies to Total Productive Maintenance	28 (5F/23M)
17/05/2023 - A	Quality 4.0	Act U.3.2 Non-Conformities RCA and Quality gates design	30 (7F/23M)
18/05/2023 - M	Maintenance 4.0	Act 1.1 Use cases of eXtended Reality (XR) in Smart Maintenance 4.0 contexts	22 (7F/15M)
18/05/2023 - A	Production 4.0	Act 3.4 Data-driven planning/scheduling models and algorithms	15 (6F/9M)
18/05/2023 - A	Quality 4.0	Act U.3.3 IoT and BPM for Integrated VSM	15 (2F/13M)

The analysis of the industrial representatives' feedback is summarized in the following Boxplot diagram (Figure 13). The average evaluation of all the presented activities was higher than 4.

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Figure 13: Evaluation results from industrial representatives in the UIT training session

Session 3:
Partner Country Institution: International Institute of Technology (IIT, Sfax – Tunisia)
Dates: from 02/10/2023 to 06/10/2023
Total number of trained industrial representatives: 09
Gender balance: 09 Males and 0 Females
Details about the presented activities and the participation of industrial representatives as presented in the following table (Table 7).

Table 7: Train industrial representatives schedule in IIT

Date	Domain	ENHANCE Training Activities	Nr. Industrial representatives
02/10/2023 - A	Maintenance 4.0	Act 1.3 Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 context	9 (0F/9M)
02/10/2023 - A	Maintenance 4.0	Act U.1.3 ML and application for maintenance	9 (0F/9M)
03/10/2023 - M	Production 4.0	Act 4.2 VSM for production 4.0	9 (0F/9M)
03/10/2023 - M	Production 4.0	Act 4.4 KPI, Dashboarding and data visualisation	9 (0F/9M)
03/10/2023 - A	Maintenance 4.0 Production 4.0	Act 1.2 Sensor Network Design in Smart Maintenance 4.0 contexts Act U.2.3 CPS design and development	9 (0F/9M)
03/10/2023 - A	Production 4.0 Maintenance 4.0	Act 3.5: Big data and predictive inventory analytics Act U.1.2 Data acquisition and storage in industry 4.0	9 (0F/9M)
04/10/2023 - M	Maintenance 4.0	Act 1.1 Use cases of eXtended Reality (XR) in Smart Maintenance 4.0 contexts	9 (0F/9M)

Date	Domain	ENHANCE Training Activities	Nr. Industrial representatives
04/10/2023 - A	Quality 4.0	Act U.3.3 IoT and BPM for Integrated VSM	9 (0F/9M)
04/10/2023 - A	Production 4.0	Act 3.4 Data-driven planning/scheduling models and algorithms	9 (0F/9M)
05/10/2023 - M	Quality 4.0	Act 5.2 Non-Conformities RCA and Quality gates design	9 (0F/9M)
05/10/2023 - M	Quality 4.0	Act U.3.2 Non-Conformities RCA and Quality gates design	8 (0F/8M)

The analysis of the industrial representatives' feedback is summarized in the following Boxplot diagram (Figure 14). The average evaluation of all the presented activities was higher than 4.
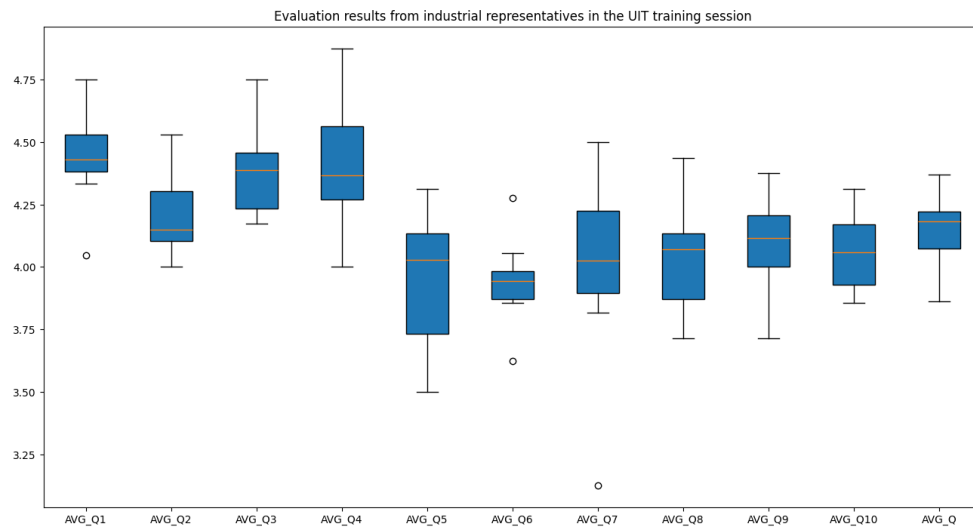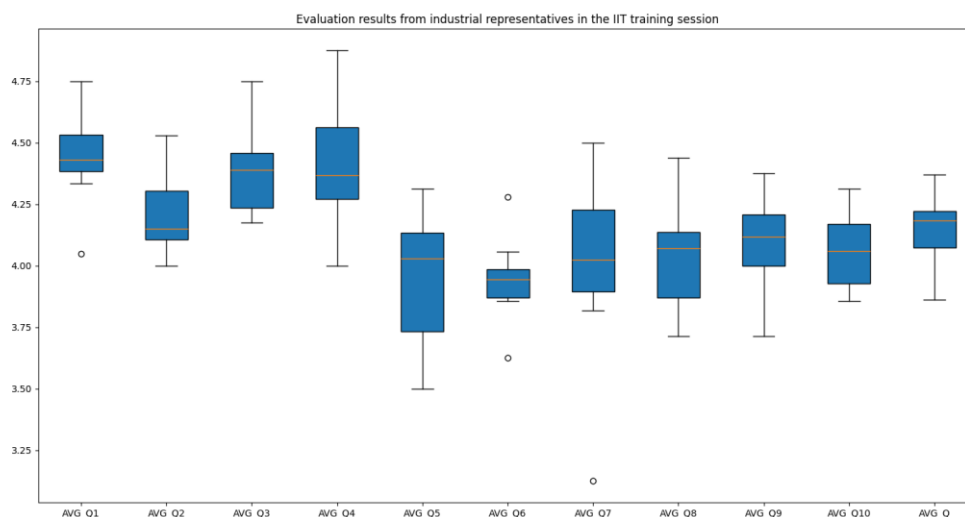

Figure 14: Evaluation results from industrial representatives in the IIT training session

Session 4:
Partner Country Institution: University of Carthage (UCAR - FSEGN, Nabeul – Tunisia)
Dates: from 27/11/2023 to 01/12/2023
Total number of trained industrial representatives: 28
Gender balance: 22 Males and 6 Females
Details about the presented activities and the participation of industrial representatives as detailed in the following table (Table 8):

Table 8: Train industrial representatives schedule in UCAR

Date	Domain	ENHANCE Training Activities	Nr. Industrial representatives
27/11/2023 - M	Production 4.0	Act 4.4: KPI, Dashboarding and data visualisation	7 (0F/7M)

Date	Domain	ENHANCE Training Activities	Nr. Industrial representatives
27/11/2023 - M	Maintenance 4.0	Act 1.3: Failure Modes, Effects & Criticality Analysis (FMECA) in Smart Maintenance 4.0 context	3 (0F/3M)
27/11/2023 - A	Maintenance 4.0	Act U.1.3: ML and application for maintenance	3 (0F/3M)
27/11/2023 - A	Production 4.0	Act U.1.2: Data analytics for inventory management Data-driven inventory management	2 (0F/2M)
28/11/2023 - M	Maintenance 4.0	Act 1.1: Use cases of eXtended Reality (XR) in industry	6 (0F/6M)
28/11/2023 - A	Quality 4.0	Act 5.2: Non-Conformities RCA and Quality gates design	5 (1F/4M)
29/11/2023 - M	Quality 4.0	Act. U. 3.2: Non-Conformities RCA and Quality gates design	11 (2F/9M)
29/11/2023 - M	Quality 4.0	Act. 4.2: VSM for production 4.0	7 (1F/6M)
29/11/2023 - A	Maintenance 4.0 Production 4.0	Act 1.2 Sensor Network Design in Smart Maintenance 4.0 contexts Act U.2.3: IoT/CPS development, integration, Interoperability, visibility, connectivity	16 (4F/12M)

The analysis of the industrial representatives' feedback is summarized in the following Boxplot diagram (Figure 15). The average evaluation of all the presented activities is between 3.75 and 4.
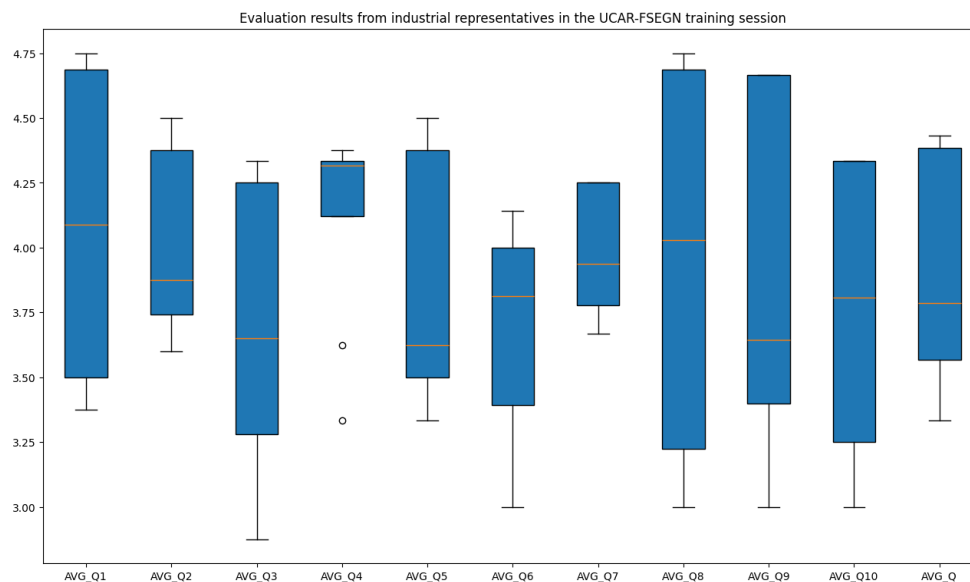
Figure 15: Evaluation results from industrial representatives in the UCAR-FSEGN training session

5. Quality audit of the adaptation/extension process

This quality audit aims at assessing the activity's consumption to enhance the current HEI programmes. A first analysis will focus on the list of selected activities by each HEI partner and how these activities

are used to enhance current programmes. The second analysis aims to assess the overall consumption level of all activities by all the partners of the project.

5.1. Activity's consumption by HEI partner

Two types of activity's consumption are considered in this analysis:

- The first one concerns the consumption to adapt the content of the current courses without adding any courses hours.
- The second one concerns the extension of the current courses by adding new content related to the activity. In this case, new courses hours will be added to the initial courses load.

The activity's consumption by each partner is presented in the following sessions. This presentation allows defining for each partner the number of updated courses, the number of used activities, the total number of hours for extension, the number of adopted hours.

Partner Country 1 - IIT
Partner Country Institution: International Institute of Technology (IIT, Sfax – Tunisia)
Total number of updated courses: 15 courses
Total number of selected activities: 18 activities
Total number of added hours for extension: 33 hours
Total number of adopted hours: 84 hours
The Consumption details are presented in the following table (Table 9).

Table 9: Consumption of training activities in IIT

ENHANCE activities	Impacted program course	Current Nr of Hours per course	Nr of Consumed hours	Type of consumption
Act U.3.1	Option IOT	15	8	Extension
Act U.2.3	Technologie des systèmes logistiques et de productions	21	10	Adaptation
Act 5.2	Internal Quality Control	21	4	Extension
Act 4.4	Workshop en Genie Industriel	21	2+6	Adaptation + Extension
Act 5.5	Control Interne et procédures	30	4	Adaptation
Act 3.1	Planification et ordonnancement	60	10	Adaptation
Act 3.2	Big Data / Cloud for system control, planning, and scheduling	21	10	Adaptation
Act 1.3	Maintenance Management Systems	24	6	Extension
Act U.2.1	Workshop en G Indus	30	6	Adaptation
Act 5.3	MSP	36	2+2	Adaptation + Extension
Act U.3.3	Introduction au G Indus	30	6	Adaptation
Act 2.4 Act 2.2	Maintenance Management Systems	30	4	Adaptation
Act U.2.4	Technologie des systèmes logistiques et de productions	21	4	Adaptation

ENHANCE activities	Impacted program course	Current Nr of Hours per course	Nr of Consumed hours	Type of consumption
Act U.1.3	Reliability and predictive maintenance	30	4	Adaptation
Act U.3.5	Artifical Intelligence	30	6	Adaptation
Act U.2.1	Option IOT	15	7	Extension
Act 3.4	DataMining	21	6	Adaptation
Act 2.5	Big Data / Cloud for system control, planning, and scheduling	21	21	Adaptation
Act 3.5				
Act 4.2				
Act U.2.5				

Partner Country 2 - UIT

Total number of updated courses: 29 courses

Total number of selected activities: 21 activities

Total number of added hours for extension: 60 hours

Total number of adopted hours: 66 hours.

The Consumption details are presented in the following table (Table 10).

Table 10: Consumption of training activities in UIT

ENHANCE activities	Impacted program course	Current Nr of Hours per course	Nr of Consumed hours	Type of consumption
Act 2.2	Maintenace industrielle	26	4	Adaptation
Act 2.4	Maintenace industrielle	26	4	Adaptation
Act 1.2	Capteurs et instrumentations	54	6	Adaptation
Act 3.3	Gestion de production	54	4	Adaptation
Act 5.5	Gestion de production	54	4	Adaptation
Act U.2.1	Système d'information logistique	28	2	Adaptation
Act 5.3	Demarche qualité	26	4	Adaptation
Act U.3.1	Instrumentations et capteurs	54	4	Adaptation
Act 5.2	Demarche qualité	26	4	Adaptation
Act 2.2	Maintenace industrielle	26	4	Adaptation
Act 2.4	Ingénierie de Maintenance 4.0	20	4	Extension
Act 1.2	Capteurs et instrumentations	54	4	Adaptation
Act 1.4	Efficacité énergétique et résistance des matériaux	20	4	Extension

Act U.3.3	Gestion de production	54	4	Adaptation
Act U.1.3	Machine Learning et systèmes multi agents	20	4	Extension
Act U.1.1	Robotique, automatisme et vision industrielle	20	4	Extension
Act 4.4	BIG DATA, Datawerhouse, Datamining	20	4	Extension
Act 3.3	Gestion de production	54	4	Adaptation
Act 5.5	Modélisation et simulation des chaines de fabrication, d'assemblage et de logistique	20	4	Extension
Act 4.3	Fabrication additive, réalité augmentée et virtuelle	20	8	Extension
Act 3.2	Ingenerie de production et twin digital	20	8	Extension
Act U.2.1	Système d'information logistique	28	2	Adaptation
Act U.2.3	Internet des objets industriels (IOT) & cloud computing	20	4	Extension
Act 5.3	Demarche qualité	26	4	Adaptation
Act 4.1	Ingeniere de production et Twin digial	20	4	Extension
Act 6.4	Ingénierie de la qualité 4.0 et Lean six sigma	20	8	Extension
Act U.3.1	Instrumentations et capteurs	54	4	Adaptation
Act 4.2	Modélisation et simulation des chaines de fabrication, d'assemblage et de logistique	20	8	Extension
Act 5.2	Demarche qualité	26	4	Adaptation

Partner Country 3 - UCAR

Total number of updated courses: 19 courses
Total number of selected activities: 18 activities
Total number of added hours for extension: 0 hours
Total number of adopted hours: 109 hours.
The Consumption details are presented in the following table (Table 11).

Table 11: Consumption of training activities in UCAR

ENHANCE activities	Impacted program course	Current Nr of Hours per course	Nr of Consumed hours	Type of consumption
Act 5.2	Référentiels QSE et Outils Qualité	42	2	Adaptation
Act 5.2	Projet tutoré	21	2	Adaptation
Act 5.2	Démarche DMAIC	21	2	Adaptation
Act U.3.2	Projet tutoré	21	2	Adaptation

Act U.3.2	Référentiels QSE et Outils Qualité	42	2	Adaptation
Act 4.4	Management des Risques et Tableau de Bord	21	2	Adaptation
Act 4.2	Référentiels Analyse des Flux: VSM -JIT	42	2	Adaptation
Act U.3.3	Lean Management	21	2	Adaptation
Act U.3.3	Référentiels Analyse des Flux: VSM -JIT	42	2	Adaptation
Act 6.3	Maitrise statistiques des Procédés	42	2	Adaptation
Act 2.3	Lean Management	21	2	Adaptation
Act 5.2	AIMA	42	2	Adaptation
Act U.1.3	AIMA	42	2	Adaptation
Act 3.5	AIMA	42	2	Adaptation
Act 2.5	GMAO	34,5	6	Adaptation
Act U.1.3	GMAO	34,5	3	Adaptation
Act 1.2	Réseaux de capteurs et RLI	34,5	6	Adaptation
Act U.1.2	ERP MES	34,5	3	Adaptation
Act U.1.2	BD	34,5	3	Adaptation
Act 2.2	GMAO	22,5	6	Adaptation
Act 3.2	GPAO	34,5	3	Adaptation
Act 3.2	ERP MES	34,5	6	Adaptation
Act 1.4	ERP MES	34,5	3	Adaptation
Act 1.4	GPAO	34,5	3	Adaptation
Act U.2.5	MAEP	37,5	9	Adaptation
Act 1.2	Réseaux de capteurs et RLI	34,5	6	Adaptation
Act U.1.2	BD	34,5	3	Adaptation
Act U.1.2	ERP MES	34,5	3	Adaptation
Act 3.2	Ordonnancement	22,5	6	Adaptation
Act 3.5	GPAO	48,75	3	Adaptation
Act 3.5	ERP MES	34,5	3	Adaptation
Act 1.4	Commande des machines électriques	34,5	3	Adaptation

ENHANCE activities	Impacted program course	Current Nr of Hours per course	Nr of Consumed hours	Type of consumption
Act 1.4	Sureté de fonctionnement	22,5	3	Adaptation

Partner Country 4 - ECC

Total number of updated courses: 11 courses

Total number of selected activities: 19 activities

Total number of added hours for extension: 0 hours

Total number of adopted hours: 72 hours.

The Consumption details are presented in the following table (Table 12).

Table 12: Consumption of training activities in ECC

ENHANCE activities	Impacted program course	Current Nr of Hours per course	Nr of Consumed hours	Type of consumption
Act 3.1	S7-Gestion des opérations (S7-Facility & work design)	20	4	Adaptation
Act 1.1	S8-I4.0-Vision industrielle & réalité virtuelle	16	8	Adaptation
Act U.1.3	S9-GI-Fiabilité des systèmes	20	4	Adaptation
Act 1.5	S7-Product design & development	20	4	Adaptation
Act 2.2	S9-GI-Organisation de la maintenance	20	4	Adaptation
Act U.1.2	S8-I4.0-Communication et réseaux industriels, internet des Objets (IoT)	16	4	Adaptation
Act 1.3	S9-GI-Organisation de la maintenance	20	4	Adaptation
Act U.2.1	S9-GI-Simulation	20	4	Adaptation
Act 6.1	S9-GI-Modélisation d'entreprise	20	4	Adaptation
Act 1.2	S8-I4.0-Communication et réseaux industriels, internet des Objets (IoT)	16	4	Adaptation
Act U.1.1	S8-I4.0-Communication et réseaux industriels, internet des Objets (IoT)	16	4	Adaptation
Act 2.4	S9-GI-Fiabilité des systèmes	20	4	Adaptation
Act U.1.4	S9-GI-Lean Six Sigma	20	4	Adaptation
Act 3.5	S9-GI-Advanced operations management	20	4	Adaptation
Act U.2.4	S7-Gestion des opérations (S7-Facility & work design)	20	4	Adaptation
Act 6.4	S9-GI-Lean Six Sigma	20	4	Adaptation
Act U.3.5	S9-GI-Lean Six Sigma	20	4	Adaptation

5.2. Overall consumption level of all activities by all the partners of the project

This second audit aims at assessing the overall consumption of all activities. Based on the list of activity's consumption presented in the previous section, we can notice that 34 activities among 42 ones are consumed totally or partially by the different partners with a consumption level equal to 79%. The number of each activity selection (which represents the number of partners selecting the same activity) differs from one activity to another. The figures below represent the consumed activities and the number of HEI partners using each activity. The first figure (Figure 16) represents the courses activities while the second one (Figure 17) represents the uses case activities.
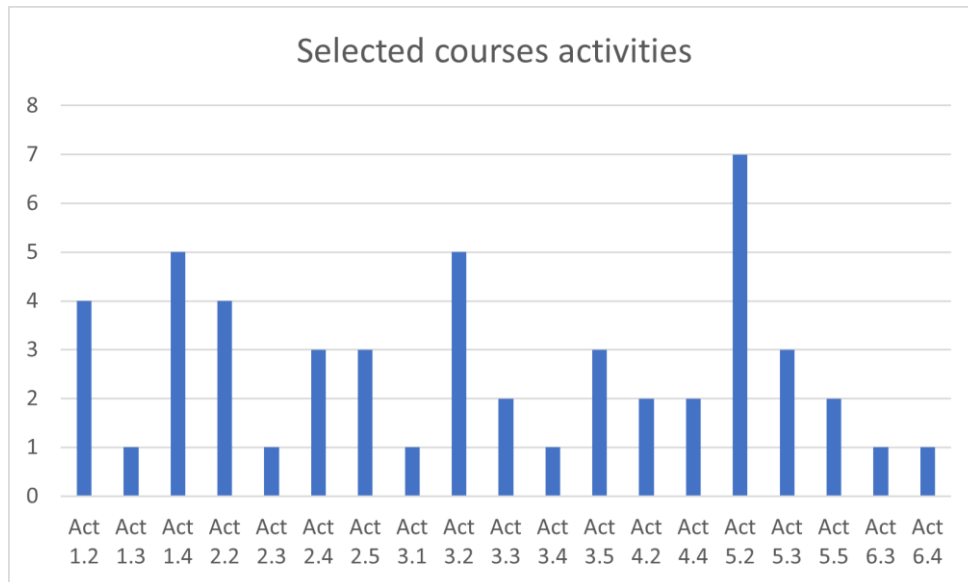

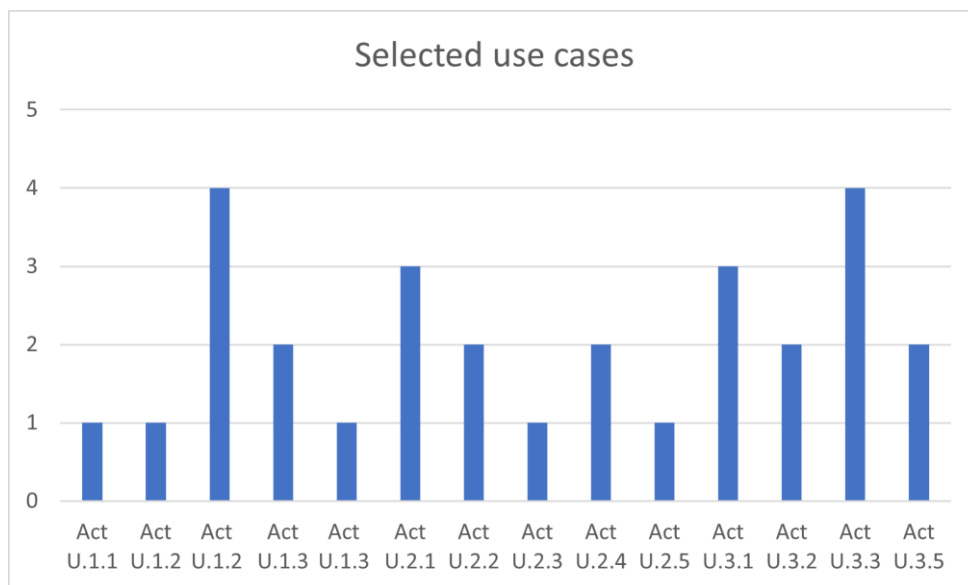Figure 16: Consumption of selected training activities

Figure 17: Consumption of selected training use case activities

6. Quality audit of the effective equipment consumption

This quality audit aims to assess the consumption of purchased equipment when the activities are used to enhance the HEI partners curricula. The objective is to ensure that each equipment is used at least one time by the concerned partner. This audit permits to present at the first time the list of equipment used for each activity's consumption per HEI partner and at the second overall consumption of each equipment. The global list of purchased equipment is presented in the following table (Table 13).

Table 13: List of equipment purchased during the ENHANCE project.

Equipment number	Equipment	HEI Partner			
		IIT	UCAR	UIT	ECC
1	FischerTechnik Learning Factory	X	X	X	X
2	Technivib simulator Expert				X
3	ESP32-CAM WiFi Module	X	X		
4	100 * RFID Adhesive readers, 50x50mm RFID	X	X		
5	RFID USB ID reader	X	X		
6	Sensor kit V2.1 42IN1	X	X		
7	Development kits	X	X		
8	Camera 5.0MP Jetson Nano	X	X		
9	KIT EDUCATION LoRa 868MHZ IOT DRAGINO Pour Arduino	X	X		
10	Kit Raspberry PI4 2G official		x		
11	Server	X	X		
12	PC Notebooks	X			
13	Tablet - Android 10 - 32 Go	X	X	X	
14	Screen for PC	X	X		
15	Car robot for Raspberry Pi 4	X	X		
16	TINKERKIT BRACCIO ROBOT TO-5000	X	X		
17	Oculus Quest 2		X		
18	3D printer	X			
19	3D Scanner Creality CR-SCAN 01 Upgraded Kit	X			
20	CNC lazer machine LASER GS5030 50W	X			
21	FILAMENT PLA 1.75MM 1KG BLEU	X			
22	STM32F407G-DISC1		X		
23	Development kit SX1278 E32-868T20D 868mhz		X		
24	Datalogic Magellan 1500i scanner			X	
25	Webcam HDR 4K Dell UltraSharp			X	
26	Duckiebot MOOC	X			
27	Arduino UNO Kit	X			
28	Automation system simulation			X	

6.1. Activity-equipment consumption by partner

The following subsections present for each activity's consumption the list of used equipment by partner. This presentation permits also to know the list of activity's consumption without the need to use equipment.

Equipment's consumption by IIT

Total number of used equipment: 20 equipment.

Total number of consumptions where at least one equipment is used: 15.

Total number of consumptions without using equipment: 5.

The mapping between consumed training activities and the purchased equipment at the IIT is summarized in the following table (Table 14).

Table 14: Connection between consumed activities and purchased equipment in IIT

ENHANCE activity	Impacted program course	Consumed equipment
Act U.3.1	Option IOT	10; 15;16
Act U.2.3	Technologie des systèmes logistique et de productions	1;6;21;26;27
Act 5.2	Internal Quality Control	1;6;21;26;27
Act 4.4	Workshop en G Indus	6;18;19;20
Act 5.5	Control Interne et procédures	1;6;7;8;9;11-14
Act 3.1	Planification et ordonnancement	1;6;7;11;15-21
Act 3.2	Big Data / Cloud for system control, planning, and scheduling	1;21
Act 1.3	Maintenance Management Systems	NO
Act U.2.1	Workshop en G Indus	6-9;11-14;18-20
Act 5.3	MSP	27;28
Act U.3.3	Introduction au G Indus	NO
Act 2.4	Maintenance Management Systems	7;9;11;12;13;14;15;16;
Act U.2.4	Technologie des systèmes logistique et de productions	8;9;12;13;14;15;16
Act 2.2	Maintenance Management Systems	1;18;21
Act U.1.3	Reliability and predictive maintenance	NO
Act U.3.5	Artificial Intelligence	1;3;4; 5;8;9;10;12;13;14;21
Act U.2.1	Option IOT	6;7;8;9;11;12;13;14;18;19;20
Act 3.4	DataMining	1;6;8;9;12;13;14;21
Act 3.5		
Act 4.2	Big Data / Cloud for system control, planning, and scheduling	No
Act U.2.5		

Equipment's consumption by UCAR

Total number of used equipment: 17 equipment.

Total number of consumptions where at least one equipment is used: 19.

Total number of consumptions without using equipment: 8.

The mapping between consumed training activities and the purchased equipment at the UCAR is summarized in the following table (Table 15).

Table 15: Connection between consumed activities and purchased equipment in UCAR

ENHANCE activities	Impacted program course	Consumed equip. Theo
Act 5.2	Référentiels QSE et Outils Qualité	1;15;16
Act 5.2	Projet tutoré	1;15;16
Act 5.2	Démarche DMAIC	1;15;16
Act U.3.2	Projet tutoré	1;3;4;6;7;8;10;15;16
Act U.3.2	Référentiels QSE et Outils Qualité	1;3;4;6;7;8;10;15;16
Act 4.4	Management des Risques et Tableau de Bord	17
Act 4.2	Référentiels Analyse des Flux: VSM -JIT	1;6;7;10;15;16
Act U.3.3	Lean Management	NO
Act U.3.3	Référentiels Analyse des Flux: VSM -JIT	NO
Act 6.3	Maitrise statistiques des Procédés	NO
Act 2.3	Lean Management	1;15;16
Act 5.2	AIMA	1;15;16
Act U.1.3	AIMA	8
Act 3.5	AIMA	1;6;7;10;15;16
Act 2.5	GMAO	NO
Act U.1.3	GMAO	8
Act 1.2	Réseaux de capteurs et RLI	1;15;16
Act U.1.2	ERP MES	1;4;5;6;7;9;10;11;12;13;14;15;16;22;23
Act U.1.2	BD	1;4;5;6;7;9;10;11;12;13;14;15;16;22;23
Act 2.2	GMAO	1;15;16
Act 3.2	GPAO	1;4;5;15;16
Act 3.2	ERP MES	1;4;5;15;16

Act 1.4	ERP MES	NO
Act 1.4	GPAO	NO
Act U.2.5	MAEP	9;11;12;13;14;22;23
Act 1.2	Réseaux de capteurs et RLI	1;15;16
Act U.1.2	BD	1;4;5;6;7;9;10;11;12;13;14;15;16;22;23
Act U.1.2	ERP MES	1;4;5;6;7;9;10;11;12;13;14;15;16;22;23
Act 3.2	Ordonnancement	1;4;5;15;16
Act 3.5	GPAO	1;6;7;10;15;16;17
Act 3.5	ERP MES	1;6;7;10;15;16; 17
Act 1.4	Commande des machines électriques	NO
Act 1.4	Sureté de fonctionnement	NO

Equipment's consumption by ECC

Total number of used equipment: 2 equipment.

Total number of consumptions where at least one equipment is used: 11.

Total number of consumptions without using equipment: 6.

The mapping between consumed training activities and the purchased equipment at the ECC is summarized in the following table (Table 16).

Table 16: Connection between consumed activities and purchased equipment in ECC

ENHANCE activities	Impacted program course	Consumed equip. Theo
Act 3.1	S7-Gestion des opérations (S7-Facility & work design)	1
Act 1.1	S8-I4.0-Vision industrielle & réalité virtuelle	1;2
Act U.1.3	S9-GI-Fiabilité des systèmes	1
Act 1.5	S7-Product design & development	NO
Act 2.2	S9-GI-Organisation de la maintenance	NO
Act U.1.2	S8-I4.0-Communication et réseaux industriels, internet des Objets (IoT)	1;2
Act 1.3	S9-GI-Organisation de la maintenance	2
Act U.2.1	S9-GI-Simulation	NO
Act 6.1	S9-GI-Modélisation d'entreprise	NO
Act 1.2	S8-I4.0-Communication et réseaux industriels, internet des Objets (IoT)	1;2

Act U.1.1	S8-I4.0-Communication et réseaux industriels, internet des Objets (IoT)	1;2
Act 2.4	S9-GI-Fiabilité des systèmes	1
Act U.1.4	S9-GI-Lean Six Sigma	1
Act 3.5	S9-GI-Advanced operations management	NO
Act U.2.4	S7-Gestion des opérations (S7-Facility & work design)	NO
Act 6.4	S9-GI-Lean Six Sigma	1
Act U.3.5	S9-GI-Lean Six Sigma	1

Equipment's consumption by UIT

Total number of used equipment: 5 equipment.
Total number of consumptions where at least one equipment is used: 19.
Total number of consumptions without using equipment: 9.
The mapping between consumed training activities and the purchased equipment at the UIT is summarized in the following table (Table 17).

Table 17: Connection between consumed activities and purchased equipment in UIT

ENHANCE activities	Impacted program course	Consumed equip. Theo
Act 2.2	Maintenace industrielle	13;24;25;28
Act 2.4	Maintenace industrielle	1;13;25;28
Act 1.2	Capteurs et instrumentations	1;13;24;25;28
Act 3.3	Gestion de production	1;13;24;25
Act 5.5	Gestion de production	NO
Act U.2.1	Système d'information logistique	NO
Act 5.3	Demarche qualité	NO
Act U.3.1	instrumentations et capteurs	1;13;25;28
Act 5.2	Demarche qualité	24;25
Act 2.2	Maintenace industrielle	13;24;25;28
Act 2.4	Ingénierie de Maintenance 4.0	1;13;25;28
Act 1.2	Capteurs et instrumentations	1;13;24;25;28
Act 1.4	Efficacité énergétique et résistance des matériaux	13;25;28
Act U.3.3	Gestion de production	NO

Act U.1.3	Machine Learning et systèmes multi agents	NO
Act U.1.1	Robotique, automatisme et vision industrielle	1;13;24;25;28
Act 4.4	BIG DATA, Datawerhouse, Datamining	NO
Act 3.3	Gestion de production	1;13;24;25
Act 5.5	Modélisation et simulation des chaines de fabrication, d'assemblage et de logistique	NO
Act 4.3	fabrication additive, réalité augmentée et virtuelle	13;24;25
Act 3.2	Ingenerie de production et twin digital	1;13;25;28
Act U.2.1	système d'information logistique	NO
Act U.2.3	Internet des objets industriels (IOT) & cloud computing	1;13;24;25
Act 5.3	Demarche qualité	NO
Act 4.1	ingeniere de production et Twin digial	1;13;25;28
Act 6.4	Ingénierie de la qualité 4.0 et Lean six sigma	NO
Act U.3.1	instrumentations et capteurs	1;13;25;28
Act 4.2	Modélisation et simulation des chaines de fabrication, d'assemblage et de logistique	NO
Act 5.2	Demarche qualité	24;25

6.2. Overall consumption of all the equipment

This section presents an overview of the utilisation of all the equipment purchased by all the partners. We can notice, from the table (Table 18) and figure (Figure 18) below, that all the equipment is used to implement activities and enhance courses. Some equipment is heavily used mainly the ones selected by all the HEI partners like the equipment 1 "FischerTechnik Learning Factory". Other equipment is rarely used which is the case of equipment selected by only one partner such as equipment 17, 26 and 27.

Table 18: Consumption of all ENHANCE equipment

Equipment number	Number of consumptions by HEI Partner				Total number of consumption
	IIT	UCAR	UIT	ECC	
1	7	21	12	10	50
2				5	5
3	1	3			4
4	1	9			10
5	1	7			8
6	8	10			18
7	2	9			11
8	3	2			5

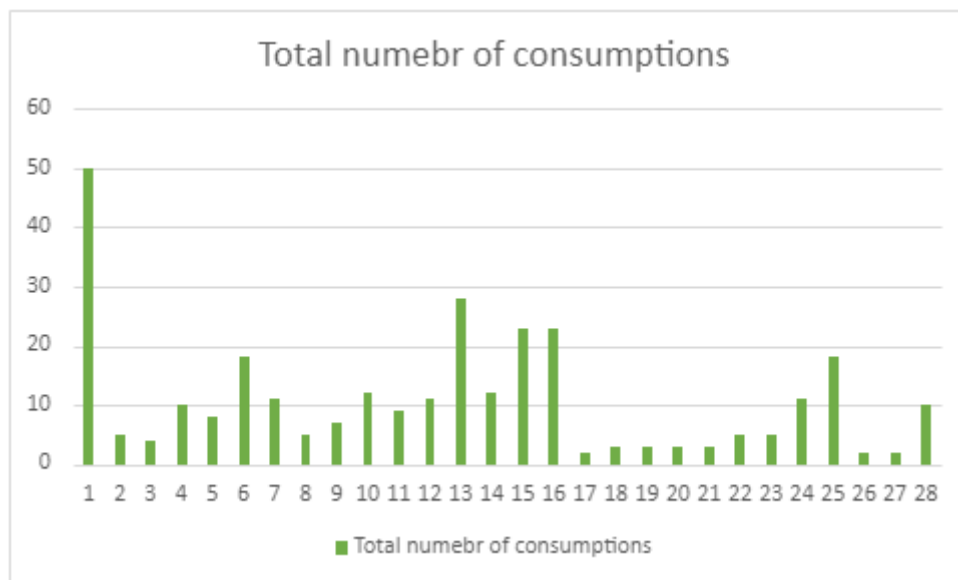|					
9	3	4			7
10	2	10			12
11	4	5			9
12	6	5			11
13	7	16	5		28
14	7	5			12
15	4	19			23
16	3	20			23
17		2			2
18	3				3
19	3				3
20	3				3
21	3				3
22		5			5
23		5			5
24			11		11
25			18		18
26	2				2
27	2				2
28			10		10

Figure 18: Consumption of equipment per training activities

7. Action plan to improve the ENHANCE training activities by/after the end of the project

Four feedback channels are proposed to improve the quality of proposed training activities:

7.1. Feedback from training activities in the eight training programmes

As presented in the section 5, the eight training programmes in Morocco and Tunisia already consume 34 activities among the 42 developed during the ENHANCE project. The consumption starts already during the 2022 - 2023 academic year for IIT and UIT partners in coherence with the train the trainer sessions. In addition, during the 2023 - 2024 academic year, the UCAR and ECC partners start the consumption of the selected training activities. All the trainers in the four PC universities are invited to communicate their feedback on the new content provided by the ENHANCE project. The collected remarks are to be shared with the activity owner to consider when improving the proposed content. Several activities (12/42) are already at the second release.

7.2. Feedback from training sessions organised with other PC Universities

During the extension period of the ENHANCE project (M37-M41), we organised two training workshops with universities, non-partners of the project, and located on different cities in Tunisia and Morocco less invested in Erasmus+ projects.
The first training workshop was organised in February 2024 in four different Tunisian universities: ISET Kasserine, FS de Gafsa, ISET Tataouine, and ISET Kebili. The four sessions attract about **222** participants between teachers, students, and industrial representatives.

Table 19: Number of participants in Tunisian workshop (four universities)

Visited Universities in TN	Participants			
	Teachers	Students	Industrials	
ISET Kasserine	1	26	2	
FS de Gafsa	15	43	3	
ISET Tataouine	13	100	0	
ISET Kebili	11	8	0	
Total	40	177	5	**222**

The second training workshop was organised in May 2024 in three different Moroccan universities: FST Fes, ENSA Fes, and ENSA de Tanger. Both sessions attract about **156** participants between teachers, students, and industrial representatives.

Table 20: Number of participants in Moroccan workshop (three universities)

Visited Universities in MA	Participants			
	Teachers	Students	Industrials	
FST Fes	5	34	0	
ENSA Fes	0	13	3	
ENSA Tanger	9	89	3	
Total	14	136	6	**156**

During both workshops, the involved teachers express their interest to reuse ENHANCE training materials and improve their courses.

7.3. Feedback from training activities when consumed in the four LeL platform in the PC

The four LeL platforms will be available for the four partner countries as a training support to their daily training activities. The LeL platform monitoring module will help to assess the following KPIs:
- The number of activities consumed by the trainees.
- The number of consumptions per activity.
- The number of tasks non completed in training activities.

- The number of quizzes finalized within each consumed training activities.
- The number of quizzes non finalized within each consumed training activities.

This first set of KPIs are useful to analyse the consumption of the proposed activities and identify when activities / tasks need to be revised or improved to facilitate their consumption.

7.4. Feedback from training activities supported by the DIH

The three selected Digital Innovation Hubs will propose training activities for their industrial partners basing on the developed ENHANCE activities. These consumption channels will provide feedback on the capacity of the proposed contents to be aligned with industrials requirements, ongoing engineering projects related to industry 4.0, requested digital transformation technologies, etc.

8. Conclusion

The quality audit reports deliverables follows a quality evaluation methodology to assess the feedback of trainers and industrial representatives after the consumption of the training activities, the level of consumption of the training activities in the eight training programmes supported by PCs, and finally demonstrates the effective consumption of selected equipment to support the training activities. To ensure their sustainability, several channels were presented to contribute in improving their training activities in the future.