ManuLearn II Best Practices

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Introduction

The main goal of the ManuLearn II project is “increasing the innovation potential of the participating EIT RIS countries by enhancing the educational framework and boosting digitalization under the concept of Industry 4.0”.

Project ManuLearn II aims at increasing the innovation potential of the participating EIT RIS countries by enhancing the educational framework and boosting digitalization under the concept of Industry 4.0. The project also aims for impact across industry and academia through the promotion of gender balance and the enhancement of soft skills.

Project activities offer a practice-based Learning Model where students, researchers and companies can work together to share good practices and experiences by jointly applying solutions to industrial manufacturing challenges. Part of this model is Teaching (TF) and Learning Factories (LF) that focus both on students’ and employees’ industrial learning needs.

The aim of this document is to present the different pilot activities organized by the ManuLearn Consortium.

ManuLearn II pilot educational activities

Nine activity pilots were organized, including TFs, LFs, webinars and workshops, to address manufacturing challenges and interesting topics for the industrial partners. Digital nuggets were also organized, to support the learning activities. Different pilot activities highlighted and address digital skills, soft skills and gender balance in the manufacturing sector.

The following table provides an overview of ManuLearn pilot actions that are analyzed and explained one by one in the following sections:

EDU activity	**Organizer & Support**	**Date**	**Companies / Universities**	**Topic**
International Online Teaching Factory	CTU and LINPRA	10/11/2021 16/11/2021 23/11/2021 30/11/2021	Project partners: CTU, LINPRA External company: Gerovė	Teaching Factory challenge: Automated line of garbage bags production
International Online Academia to Industry Teaching Factory	LMS and LINPRA	4/11/2021 18/11/2021	University: Upatras	Build the Future in Additive and Hybrid Manufacturing
Physical in Spain Industry to Academia Learning Factory	IMH and Tecnalia	30/11/2021 01/12/2021	Training Expert: Josu Caminos	Standard communication protocols OPC-UA and UMATI
Academia to Academia Learning Factory	LMS	10/2021	University: Upatras	Smart Manufacturing: Robotic Resistance Spot Welding
International Online Webinar	LINPRA	25/05/2021	Companies: Novameta Sargasas Research Institute: Tecnalia	Careers in manufacturing: the importance of gender balance, soft and digital skills

Physical in Prague Learning Factory Academia to Academia	CTU	26/10/2021 02/11/2021	External Enterprise: Kovosvit MAS, Machine Tools a.s.	Machine Tool Accuracy - Methods increasing utility properties of machines
Online Teaching Factory Industry to Academia	IMH	23/11/2021 30/11/2021	External enterprise: SmartPM	Cobots, Autonomous production cell, Autonomous mobile robots
Webinar-workshop Academia to Academia	CTU and LMS	15/12/2021	Universities: CTU and Patras	Robots in production manufacturing: Virtual commissioning
Webinar	IMH	11/24/2021	IMH	Additive Manufacturing

“Industry to Academia” Teaching Factory – Pilot 1

Description

CTU in Prague (RCMT) together with Ambassador of engineering industries of Lithuania (LINPRA) organised a Teaching Factory (TF) challenge on “Design an automated line of garbage bags production to avoid manual work”. The event was international with the support (challenge setter) of Lithuanian company Packaging Emigration (powered by Gerove), polyethylene products producer, recycler and wholesale operator. The event was handled as hybrid (meeting with the company were online, internal discussions and solution preparations were physical). The topic from automation and robotic field reflects actual need of specific industry subject seeking to improve productivity and reduce the risk of defects.

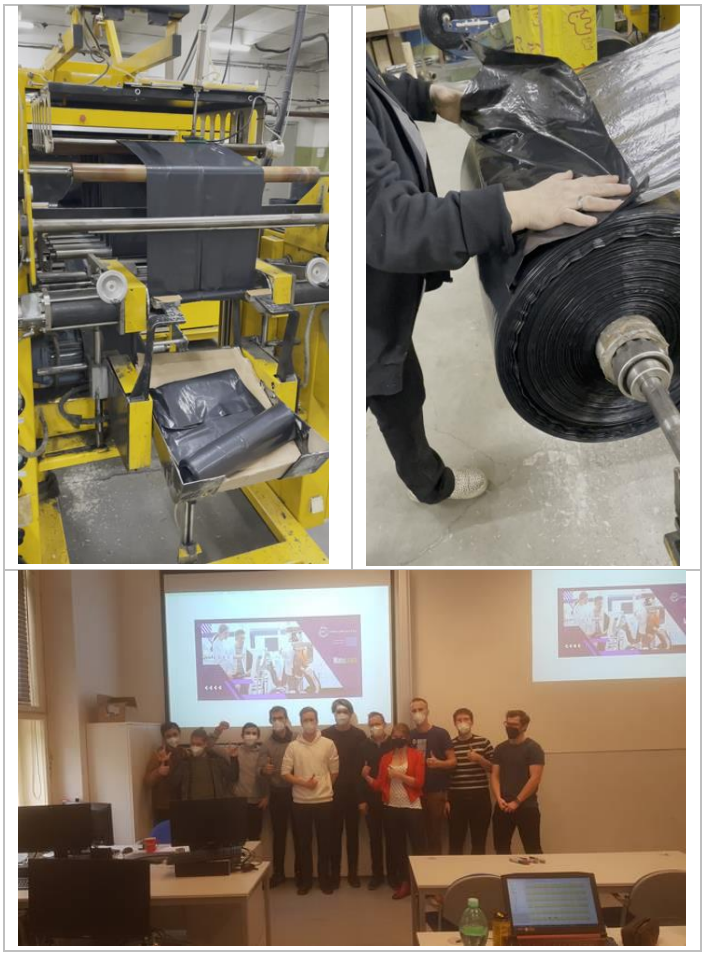
Challenges and needs

High level of automation is one of the main factors involving productivity in specific industry area such as eco-responsible packaging material production. The ‘contracting’ company in TF challenge was seeking for a general solution. This task was further narrowed to specific needs and challenge: company needs a solution how to make changing of rolls on running machine. There is loss of a lot of material and time due to manual changing process of a roll. Outline of an attachment to existing converting machine in order to change a roll without stopping the machine would be appreciated solution. Cooperation with real industry representatives upon actual topic really needed to be solved was the main motivation for participants to enrol into the challenge.

Methodology

The challenge was offered to CTU students voluntarily as a part of their regular subject on Term Project in design and construction of machine tool parts. The potential target group of participants was selected by LINPRA choice of necessary background in *Industrial robotics and manipulators* out of CTU student concern list. Participants were divided into groups (3 to 4 people). Each group elected a leader whom main task was collecting questions and communication with authorities. This way shows up as a very effective. Beside industrial partner representative to address a questions, CTU offered participants a consultant who is an expert in the field. The role of consultant was to discuss solutions and provide feedback concerning feasibility of purposed ideas. The process was structured in 4 sessions:

- Session I, “Challenge set-up”, online
- Session II, “Internal meeting and discussion”, physical
- Session III, “Solution presentations”, online
- Session IV, “Company feedback”, online



Learning Outcomes

From this TF, participants were facing issue from real industry. Emphasised were two different demands put on participants. Firstly, relatively quick orientation in the company problem setup and find appropriate hard skills to implement for formulation appropriate questions with necessary background, making reasonable resources research and reaching successful solution. Secondly, exploitation of soft skills to formulate additional questions in intelligible manner, work in team, present solution in front of authority and to face a certain or possible critical reaction. Since the research teams were led by participants themselves (not by an authority), participants had whole responsibility for their work and effort. Moreover, attendees received feedback from the very interested industrial partner in their solutions, providing an awareness that their work might be useful.

“Academia to Industry” Teaching Factory – Pilot 2

Description

LMS organised a teaching factory on “Build the Future in Additive and Hybrid Manufacturing”. Techranga, a machining manufacturer from Lithuania, was identified and approached by LINPRA and InTechCentras. The company is interested in expanding its facilities into additive manufacturing and hybrid manufacturing, thus the teaching factory was tailormade to assess its specific needs.

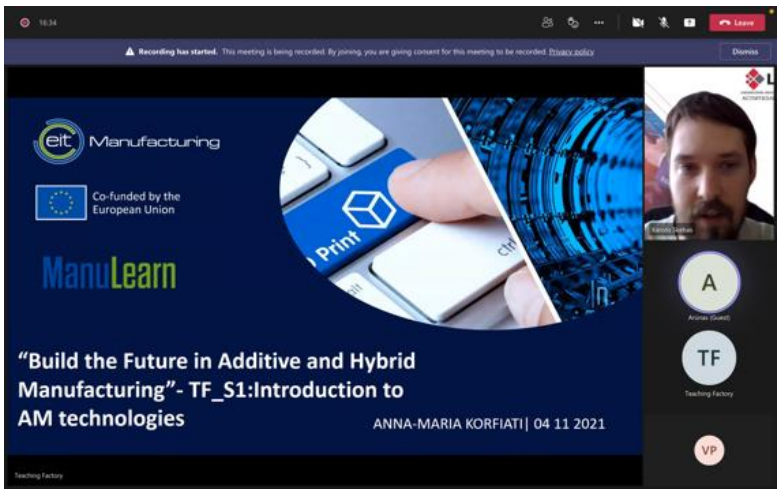
Challenges and needs

Additive and hybrid manufacturing processes are novel technologies, with limited industrial implementation. There are still some challenges such as high cost, lack of skilled workforce, limited variety of machine tools, but most importantly, the industrial partners have limited knowledge on the principles of additive and hybrid manufacturing and their potential. This is where the teaching factory aims, to fill the gap, to inform industrial partners and to provide solutions.

Methodology

The activity took place on two days (4th November 2021 and 18th November 2021) on two specific topics that were addressed in individual sessions.

- Session I, “Introduction to Additive Manufacturing Technologies”
- Session II, “Introduction to Hybrid Manufacturing”



Learning Outcomes

From this teaching factory, the participants were introduced to additive manufacturing and hybrid manufacturing technologies. The main principles and applications were presented, but also the challenges and limitations were highlighted. Both sessions provided insight to the participants for the additive and hybrid manufacturing approaches, the implementation in industrial settings and certain drawbacks that should be taken into consideration, but also how these could be overcome

Learning Factory – Pilot 3

Description

The Learning Factory (Industry to Academia model) aims the knowledge transfer from industrial sector to academia by teaching the students real industrial problems that have been solved. In the case of this pilot activity, an expert from an automation and CNC machines company (Fagor Automation) proposed a task about "Standard Communication Protocols: OPC-UA and UMATI". Participants worked with the expert to learn how to use an OPC-UA client and to create an OPC-UA server. After, the expert showed how the MQTT protocol works, and participants discussed about communication protocols.

<u>Learning process agenda</u>

The activity consisted of two sessions, with a duration of 2 hours each, in two days in a row. The pilot activity was realised within the first part of the regular course at IMH "ASMATU" for students that couldn't start the internship in a company. Additionally, the event was announced to other parties through IMH contacts and social media. The activity was performed physically at IMH School of Dual Engineering. All the participants were from Spain, so the Learning Factory was carried out in Spanish.

Learning Outcomes

Participants learn about different industrial communication protocols and the unification efforts that have been made. Furthermore, they gain competencies in communicating with CNC machines and extracting the available data using different protocols, OPC-UA and MQTT, and different architectures.

Learning Factory – Pilot 4

Description

LMS organized a learning factory on “Resistance Spot Welding”, where students from the Department of Mechanical Engineering and Aeronautics, University of Patras, were introduced in the topic via two session.

Challenges and needs

Undergraduate and MSc students from the Department of Mechanical Engineering and Aeronautics, University of Patras, were invited to join this learning factory on “Resistance Spot Welding”, to get a glimpse on real industrial processes and problems.

Learning Process Agenda and Schedule

The learning factory was organised in two sessions in two consecutive weeks:

- Session I, virtual session on “Smart Manufacturing: Resistance Spot Welding”
- Session II, physical session on “Smart Manufacturing: Resistance Spot Welding”

The activity took place on two days, on the topic of Robotic Spot Welding. The first session (8th of October) was performed via MSTeams, while the second session offered a physical demonstration of the process in a dedicated workshop area within the facilities of LMS.

Learning Outcomes

Students learned about resistance spot welding, its principles, and applications in the industrial setting. They were also invited in a lab-based, but industrial-sized spot welding where the educator demonstrated its operation and quality monitoring. All participants found the learning factory inspiring and motivating and were satisfied by the explanation of the learning content. The learning content was rated as interesting by the participants because it met their needs. Most of the participants found the learning factory very attractive, and so was the material of the program. They found the learning factory effective and the examples given successful.

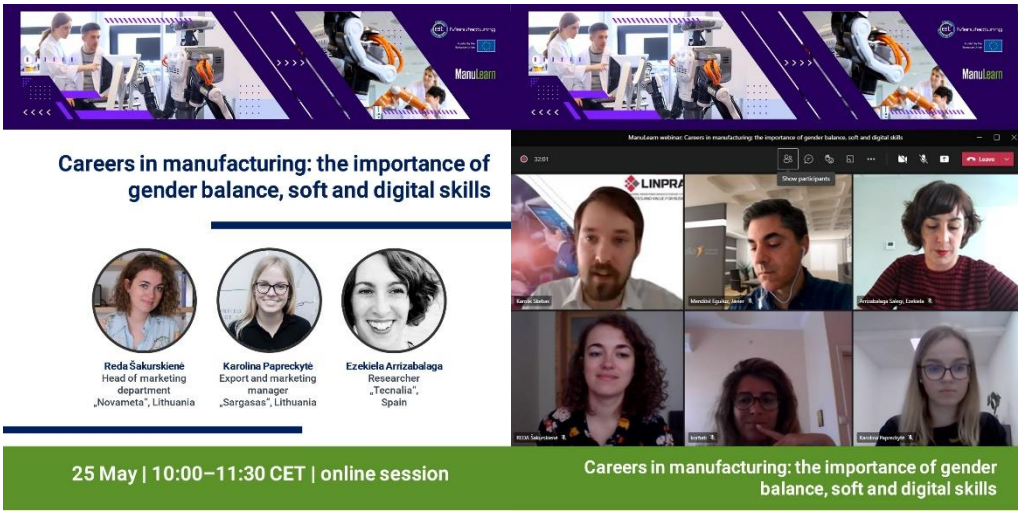
Learning Event/Webinar – Pilot 5

Description

Careers in manufacturing: the importance of gender balance, soft and digital skills

LINPRA organized an international webinar to students of partner universities, featuring representatives of European manufacturing companies, in regards of globally trending and relevant topics when talking about careers in the manufacturing field. The webinar was an online international event, aiming to increase the innovation potential in European countries by enhancing the educational framework, boosting digitalization under the concept of Industry 4.0, promoting gender balance and the enhancement of soft skills.

The webinar was more focused on women in manufacturing topic, most relevant soft skills at manufacturing company and ways of career development for a young person. Representatives of manufacturing companies and research institute were sharing their experience, insights and research results on the discourse of gender balance, as well as soft and technical skills balance, which is relevant in building careers in today's manufacturing field. Speakers in the webinar shared their career development experiences, answering how they came up to where they are now, what skills and competences are helping to be successful in the XXI century manufacturing field.



Learning Outcomes

The webinar introduced women in manufacturing and showcased examples of developing careers in engineering field by women. The audience consisted of both, women and men. The webinar was focused on soft skills and career development topic, as an experience sharing event. Participants heard real success stories and examples from women – engineering company representatives.

Learning Factory – Pilot 6

Description

CTU in Prague (RCMT) organised a learning factory (LF) on “Machine Tool Accuracy - Methods increasing utility properties of machine“. The event was held as national with support of Czech reputable machine tool builder Kovosvit MAS Machine Tools a.s. The event was physical. Selection of the LF topic was based on national strategy document analysis (deliverable A2102 of the ManuLearn II project), Kovosvit MAS company needs (gain knowledge regarding metrological habits in practise among the participants) and needs of target group (lac of hands-on experience caused by recent worldwide pandemic crisis).

Challenges and needs

Increasing demands on accuracy of final parts, rapidity and reliability of production put stress also on measurement methods and machine tool (MT) precise adjustment. The main aim of the LF pilot activity was focused on modern and conventional approaches to MT geometrical error inspections. Through hands-on experiences carried out on two conventional machines (turning and milling) and 5-axis machining centre, participants were challenged with experimental set-ups, data processing and their interpretation possibilities in MT control system with accordance to Industry 4.0 anchored principles. Outlining needs in a real business to participants was role of invited metrological expert from Kovosvit MAS company.

Learning process agenda and schedule

The LF was organised in two sessions. Both meetings were of 90 minutes duration and follow up in one-week period:

- Session I, “Stationary geometrical errors measured with machine switched off” and “Geometrical errors measured within non-stationary behaviours”
- Session II, “Stationary geometrical errors measured with active feed drives

Participants were free to choose between attend to all sessions or just one appropriate to their interest and study course. Due to a clear overview of attendees a doodle meeting schedule was created. The only attendance to both sessions can provide a comprehensive look onto MT and part accuracy inspection was mentioned in header of the doodle meeting schedule.

Learning Outcomes

From this LF, the participants were introduced to comprehensive way of geometrical error inspection of MT containing all the phases: errors independent to MT control system, errors dependent on MT feed drives and thermal errors. The conventional and modern methods and approaches were presented in hands-on experience form with measurement results and used gauges advantages and drawbacks discussions. Further, participants were provided with insight into problematics regarding Industry 4.0 requirement fulfilments. In this stage, they were exposed to the opinion of an expert from real industrial environment as well. Attendees could sharp their feelings to measuring device adjustment and reliability.

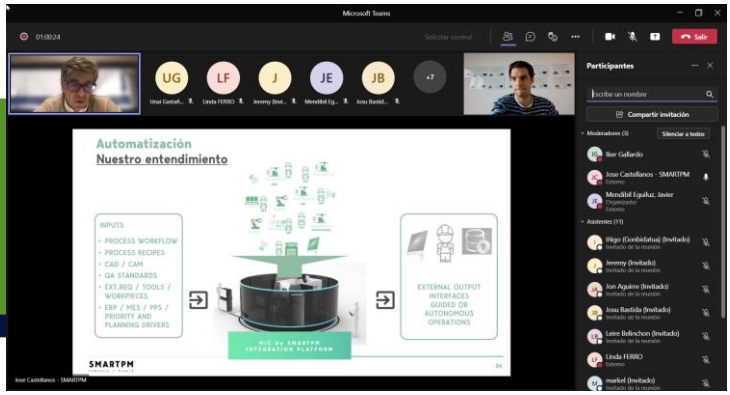
“Industry to Academia” Teaching Factory – Pilot 7

Description

The Teaching Factory (Industry to Academia model) aims the knowledge transfer from industrial sector to academia by teaching the students real industrial problems that have been solved. This pilot activity was organized by IMH and Tecnalia in collaboration with an automation spin-off company, SmartPM. In the case of this pilot activity, the general manager of SmartPM, José Castellanos, proposed a task about “Autonomous production cell”, which allowed the participants to investigate about how an automation process can be carried out.

The participants researched about a real case of use of an autonomous production cell and the process needed to implement. For that, they had the support of Jose Catellanos, Dr. Egoitz Artetxe (lecturer at IMH) and Dr. Iñigo Sesar (automation researcher at IMH).

The Teaching Factory was divided in three online meetings. A total of 19 participants were present in the meetings including the organizers from Tecnalia and IMH and collaborators from SmartPM and IMH.



Learning process agenda

The activity consisted of three online sessions, with different durations. The pilot activity was realised within the first part of the regular course at IMH “ASMATU” for students that couldn’t start the internship in a company. Additionally, the event was announced to other parties through IMH contacts and social media. The activity was performed online through MS Teams platform, which allowed individuals from outside Spain to participate.

Learning Outcomes

Participants learn about the concepts and technologies needed to create an autonomous production cell. Furthermore, they are able to identify an autonomous production cell and explain the process to transform a conventional production cell to an autonomous production cell.

Workshop – Pilot 8

Description

CTU in Prague (RCMT) together with Laboratory for Manufacturing Systems & Automation (LMS) organised a webinar "Robots in production manufacturing: Virtual commissioning". The event was international open for both industry and academia sectors. The event was handled as online (MS-Teams platform). The topic from robotic field reflects actual need of progress in digitalisation, digital twins especially. The webinar has also certain connections to Learning Factory event realised in previous EIT Manufacturing project ManuLearn.

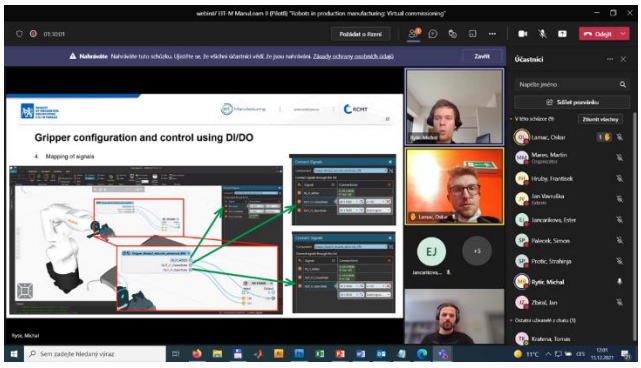
Challenges and needs

The robots in manufacturing and automation processes are an essential part of modern production with direct connection to anchored ideas of Industry 4.0. The knowledge of the optimal and secure use of robots consist of the fundamentals of robot control and capabilities, principles of inclusion robots into manufactory operation sequences, robot design for manufacturing processes, etc. Virtual commissioning is a very effective and safe approach to debug robot functionalities before real application.

Learning process agenda and schedule

The webinar was organised in one session to cover 90 min. The first draft agenda is found below:

- introduction to EIT-M and project ManuLearn II (20min)
- introduction to KUKA robots (15min)
- Creating a robot model and environment (15min, commented video and SW examples)
- Robot control from virtual platform (15min, commented video)
- Example of gripper configuration (15min, commented video, hands-on experience)



Learning Outcomes

From this webinar, participants were introduced to comparison and advantages between real and virtual environment of robot's commissioning. Participants were provide with basic knowledge of brand software for virtual commissioning of KUKA, FANUC and Stäubli robots and software used for wide range of industrial robots. The advantages and drawbacks of both approaches to virtual commissioning were discussed. Participants were clearly confronted with level of similarity between virtual and real environments with the help of robotic cell existing at CIIRC (CTU in Prague) through commented videos containing transparent example realised in both virtual and real. After the webinar, participants can understand importance

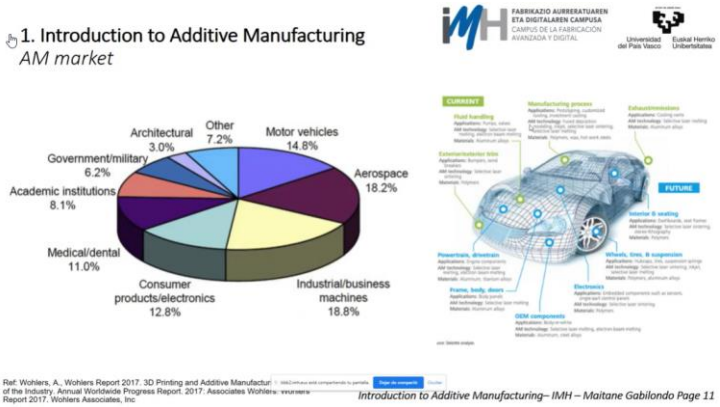
and possibilities of robot digital twin with outline of their boundaries (wide training possibilities, collision safety, pathway optimisation, robot kinematic and dynamic utilisation, programming, connection to PLC, etc.).

Webinar – Pilot 9

Description

The Webinar aims to share the knowledge about a topic to industrial and academic audience. In the case of this pilot activity, a researcher from IMH gave a webinar about “Additive Manufacturing”.

Participants in this activity were introduced to the concepts and technologies of additive manufacturing and had the opportunity to ask question about it.



<u>Learning process agenda</u>

The activity consisted of 1 session:

- Welcome and Presentation of the ManuLearn Project
- Speaker Presentation
- Additive Manufacturing, introduction, advantages and implementation in industry
- Questions

<u>Methodology</u>

This pilot activity was realised within the first part of the regular course at IMH “ASMATU” for students that couldn’t start the internship in a company. Additionally, the event was announced to other parties through IMH contacts and social media. The webinar was performed through BigBlueButton platform, which allow individuals from outside Spain to participate.

Learning Outcomes

Participants learn key concepts and main technologies of additive manufacturing. Furthermore, they can distinguish a piece fabricated by additive manufacturing respect to other manufacturing processes.