DiTwin

www.ditwin.eu

Modules

Digital Twins for VET students

YEAR:
2026

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Co-funded by
the European Union

DiTwin – Digital Twin for VET school

DiTwin Modules

The editing of this document was finished on January 2026.

Project website: https://www.ditwin.eu/

DiTwin is a Cooperation Partnership project in vocational education and training sector (KA220-VET) funded under the Erasmus+ Programme.

Project Number: 2023-1-IT01-KA220-VET-000154611

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This document has been created by the collaboration of the whole DiTwin partnership: Learnable Società Coooperativa a r.l. (IT) -project Coordinator, Digital Smart srl (IT), ETN Training Vision Ireland (IR), University of Malaga (ES). Málaga TechPark (ES), Innovation Frontiers IKE (GR), University of the National Education Commission, Krakow (PL).

Contents

Introduction

The DiTwin Modules are a product of the project DiTwin – Digital Twin for VET schools, an Erasmus+ KA2 Cooperation Partnership project in Vocational Education and Training, co-funded by the European Commission.

The document provides some digital twin-based modules addressed to secondary students (4th and 5th EQF level of education), for the achievement of knowledge, skills and competencies related to specific profiles required by Industry 4.0.

The main objective is to improve the effectiveness of VET curricula for achieving the competencies needed by Industry 4.0 by exploiting the potential of Digital Twin technology. In fact Digital Twin can bridge the gap of facilities and machinery of VET schools by creating simulated industrial systems linked to real machineries.

The DiTwin modules together with the DiTwin Competence Framework will support VET schools and teachers to continue up-skilling VET students with the competences required by Industry 4.0, connecting the VET sector to the latest developments of labour market. The main aim is to support school to work transition of VET students , preventing high unemployment rate of young people in partner countries and workforce shortcomings for the Industry 4.0 sector.

The DiTwin modules support the standard lessons, when it is necessary, to gain practical experience of the systems and machinery related to the different school subjects.

For example, at a certain point of the robotics curriculum, the teacher can decide to use the DiTwin modules to have students operate an industrial robotic arm in order to put the theoretical knowledge acquired into practice. In this case, the teacher will connect to the DiTwin platform and identify the appropriate module and lesson. Students connected with their PCs at school will have the possibility to access the digital twin based systems created by the DiTwin project and complete the lesson foreseen in the module.

The DiTwin modules are specifically created for VET schools but potential applications can be also addressed to a variety of stakeholders like associations of companies, industries 4.0, policy makers and educational Institutions.

DiTwin System – How it works

A Digital Twin is a dynamic digital replica of a physical object or process. This innovative technology connects the real world with cyberspace, enabling the sensing of objects and processes, data gathering, machine learning and real-time feedback over the connected machines.
The system created by DiTwin partnership enables hands-on and WBL activities at distance, providing the 3D simulation of a real object connected with the system. This involves many possibilities like to simply observe how a machine works in the reality or to act (through the simulation) on the real machineries connected, receiving their direct feedback.

DiTwin systems is based on 3 main labs:

01

Remote Laboratory for Additive Manufacturing

This laboratory integrates a networked 3D printer with the DiTwin Platform to facilitate additive manufacturing and computer-aided design (CAD) practices. It allows users to perform virtual simulations of 3D printing processes. The platform enables users to send generated code directly to the network-connected 3D printer and monitor the additive manufacturing process in real time via a webcam.

02

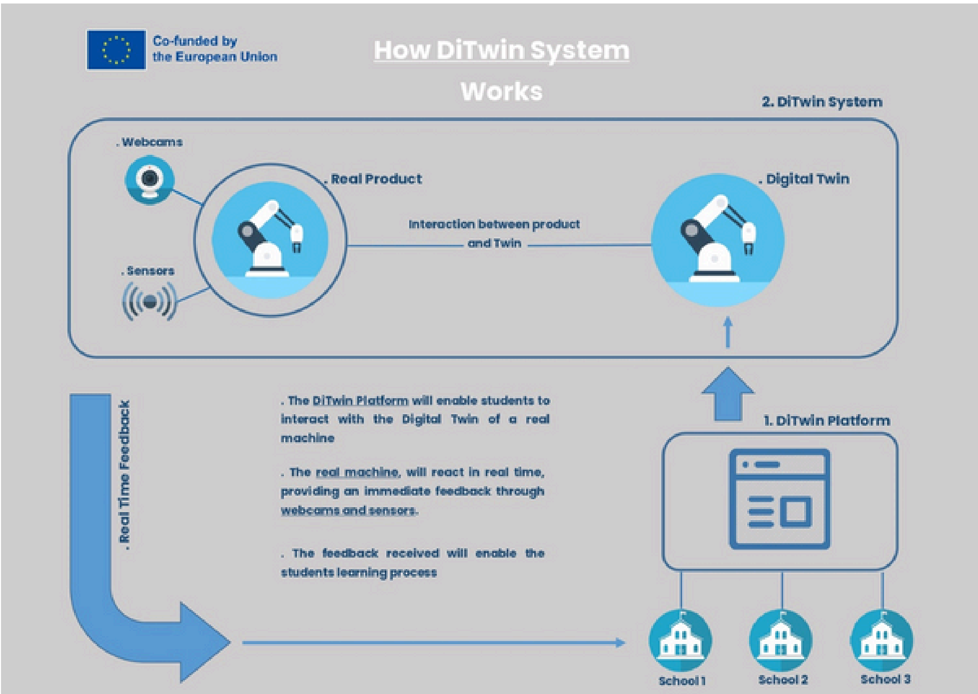
Remote Robotic Cell Laboratory

This laboratory features a robotic cell built around a cobot-type robotic arm, equipped with proximity sensors and a conveyor belt. All components are managed through the robotic arm's control unit. A digital twin of this robotic cell replicates all its functionalities, enabling students to program tasks in the digital twin environment. These tasks can then be sent to the physical robotic cell, with the execution monitored in real time through a webcam.

03 Remote Laboratory for Managing Production Processes in an Industry 4.0 Environment

This laboratory is a Cyber-Physical Factory, designed to mirror the new production paradigm of Industry 4.0. It offers a modular Smart Factory system for both teaching and research, capable of reproducing various setups of automated systems used in Industry 4.0.

The DiTwin System can be used by schools and students without the need of installing any particular software. The users can connect through the platform and directly access the lesson selected.



How to use the DiTwin Modules

The profiles covered

The modules developed align with the profiles required by Industry 4.0 in partner countries, including Italy, Spain, Ireland, Greece, and Poland. The creation of the DiTwin Modules was preceded by the definition of 11 profiles, each described using a learning outcomes approach that outlines the necessary knowledge, skills, and competences (see the Competence Framework on the project website). The identified learning outcomes for all profiles were then harmonized with the vocational education and training (VET) curricula of the partner countries, ensuring they can be seamlessly integrated into VET schools' practices.

The modules actually produced cover the following 3 profiles of the DiTwin Competence Framework:

-Profile 1. Additive Manufacturing technician
-Profile 4. Automation technician for Industry 4.0
-Profile 10. Robot machines technician for Industry 4.0

Profile 1. Additive Manufacturing technician

An Additive Manufacturing Technician is responsible for the smooth operation of 3D printing machines, including setup, maintenance, and repairs of equipment. They understand the fundamentals of additive manufacturing, the functioning of different systems, and the benefits of each technology. Key tasks include preparing and managing print files, ensuring adherence to quality standards, diagnosing and performing maintenance, and selecting appropriate printing materials for specific applications. They ensure quality control throughout the process, from preparing the system to operating basic tasks on the 3D printer.

Profile 4. Automation technician for Industry 4.0

An Automation Technician for Industry 4.0 is responsible for creating, repairing, and maintaining basic automated systems in industrial settings. They have a solid understanding of mechatronics, automation, robotics, electrical engineering, electronics, pneumatics, and hydraulics. Their role includes operating Programmable Logic Controllers (PLCs), monitoring automated production systems, performing basic repairs and maintenance, and installing automated systems. They are also skilled in describing maintenance indicators and diagnostic techniques to ensure smooth operation of automated processes.

Profile 10. Robot machines technician for Industry 4.0

The Robot Machines Technician for Industry 4.0 is responsible for setting up, operating, and maintaining robotic machines in industrial settings. They have knowledge of robot components, characteristics, and applications, and can distinguish between advanced and collaborative robots, including their types and the differences from traditional industrial robots. They can program, set up, and monitor industrial robotic arms, perform basic maintenance, and identify risks and safety issues during robot operation. They also understand maintenance indicators and diagnostic techniques to ensure optimal robot performance.

The Learning outcomes

The DiTwin modules are built on Digital Twin technology and replicate various technical systems or machinery associated with the previously described profiles. These modules focus on specific learning outcomes tied to practical and experiential learning, while broader, profile-related learning outcomes are achieved through the standard curriculum.

In many cases, the theoretical or general concepts taught during standard lessons serve as prerequisites for engaging with the DiTwin modules. These modules, which offer hands-on experiences with the machinery relevant to different profiles, can serve as the culmination of the learning path, allowing students to apply the knowledge they have acquired.

However, this does not mean that the modules are limited to practical application alone. The digital twin systems also facilitate observations and activities that help develop and reinforce both theoretical and foundational knowledge related to the selected profiles.

The Modules

How they are structured

The modules are focused on 3 out of 10 profiles identified by the DiTwin Competence Framework (download the DiTwin Competence Framework for a comprehensive understanding on www.ditwin.eu).

The three profiles have been selected based on the relevance they have considering the standard curricula in partner countries and the potential impact on the students' employability.

One module for each profile identified has been created. Every module covers some learning outcomes related to the profiles. In particular those achievable through practical and experiential learning on industry 4.0 machineries.

Every module is built on several setups (the configuration of physical spaces and machineries). Every setup can be used for one or more lessons.

Every lesson is described presenting requirements (previous knowledge needed), learning outcomes achievable, duration and the steps of the activity.

Following you can find the DiTwin Modules:

Module - Additive Manufacturing technician

Learning Outcomes covered

Knowledge

K1.1 To describe what additive manufacturing is and how the different systems work

K1.2 To recognise the advantages, opportunities and benefits of the different systems of Additive Manufacturing

K1.3 To describe the sequence of process steps

K1.4 To describe how to prepare and manage the files for printing

K1.5 To describe the quality standards and indicators of the additive manufacturing products

K1.6 To describe maintenance indicators and diagnostic techniques

K1.7 To understand the more appropriate printing material, for the specific 3D printer, with respect to the object to be printed

Skills

S1.1 To prepare and manage the files for printing

S1.2 To properly prepare and set up at least 1 additive manufacturing system

S1.3 To properly operate basic tasks using at least 1 additive manufacturing system

S1.4 To check and ensure the quality of the products

Lesson 1 - Observation of a 3D Printer at work.

Setup

Figure 1.1. Bambu Lab X1E 3D printer

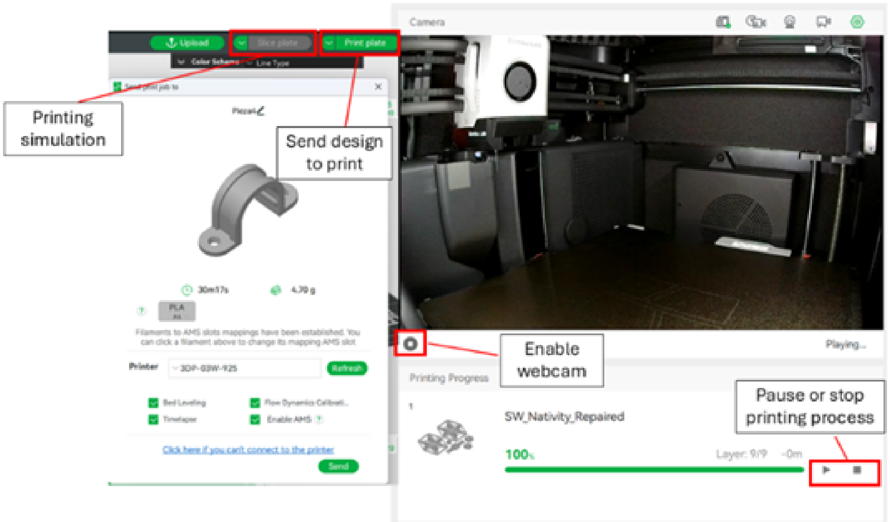


Figure 1.2. Visualise a 3D printer in operation via webcam

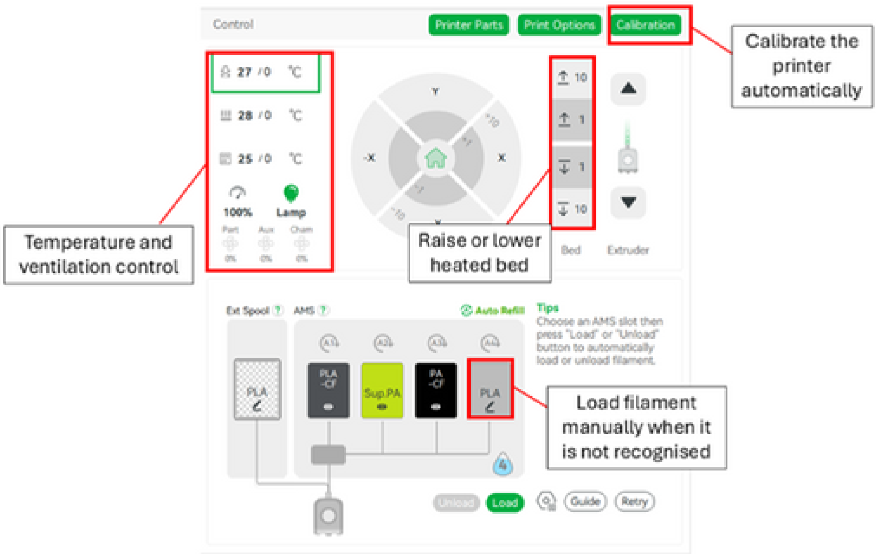


Figure 1.3. Control interface with the physical 3D printer

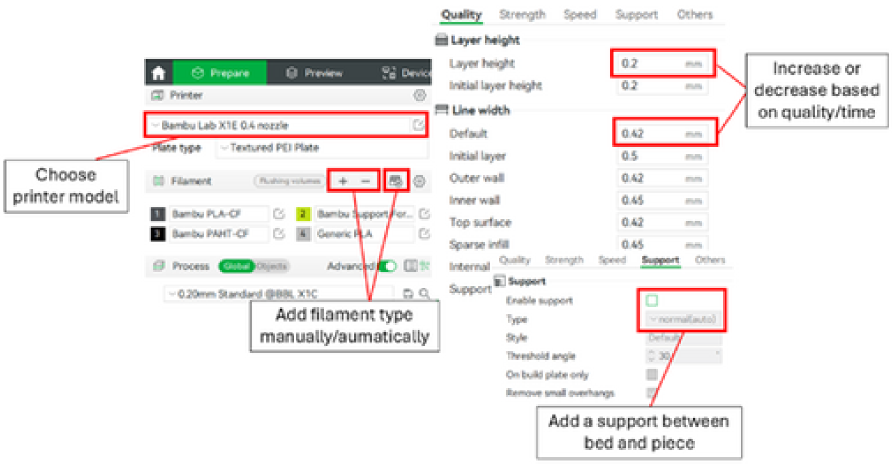


Figure 1.4. 3D printer parameter configuration

Requirements

Basic concepts of additive manufacturing in 3D Printing.

Learning Outcomes acquired

S1.1 To prepare and manage the files for printing.
S1.2 To properly prepare and set up at least 1 additive manufacturing system.

Duration of the lesson

2 hours

Activities and steps to be implemented

Using the Bambu Studio slicer application as a digital twin, the interface and the basic control commands of the Bambu Lab X1E 3D printer (Figure 1.1) will be illustrated. To achieve this, a part design file in STL format will be obtained, and then the printing process will be simulated in the software. Finally, the designed part will be sent to the printer to observe its real-time progress.

In summary, the concepts considered in this lesson are the following:

- Conversion and loading 3D printer compatible files.
- Adjustment of print parameters and 3D printer configuration.
- Simulation of the printing process of a piece.
- Control of the 3D printer through the digital twin.
- Transmission and real-time observation of the printing process.

Figure 1.2 shows a webcam image associated with the 3D printer. This webcam provides a video of the printing process at real time, and Figure 1.3 shows the control interface with information about its status. In this lesson, an initial introduction to additive manufacturing will be carried out by uploading a part design to the slicer application and finally sending it to the printer. For this, the following activities will be carried out:

1. Convert all the files provided in this lesson from OBJ to STL format, which only describes the surface geometry of the part without textures or colours, making the file lighter and easier to process. For this, use the free tool Tinkercad for loading the provided file and then exporting in STL format.

2. Configuration of printing parameters. Using the “Preview” section (see Figure 1.4), choose Bambu Lab X1E 0.4 nozzle as the printer model and select a layer height of 0.2 mm, leaving the other parameters by default. Explore the different types of filaments and create a new one of type Generic PLA in grey.

3. Printer simulation. Once the design of part 1 has been imported and its printing parameters configured, a simulation of the printing process will be carried out using the “Slice plate” option in the “Preview” section. Variables such as the printing time, the amount of material used, the printing speed at each moment, and the operating temperature are shown. Once the simulation is completed, as exercise, obtain the layer number at minute 18 using the green progress bar.

4. Prepare the real printer. Connect the webcam associated with the printer to monitor the status of the printer in real time. Figure 1.3 shows the control interface of the digital twin with the real 3D printer. This control interface includes functionalities as the calibration process, the control of the temperature of the hot bed or nozzle, activation of auxiliary ventilation, or manual movement of the extruder.

Send the designed part and visualize the printer at work. Send the code of the part to the printer and compare the difference between the printing time in simulation and in the real process. Furthermore, the printing status could be controlled, such as pausing or stopping it at any time from the digital twin.

Lesson 2 - Optimization of basic tasks in 3D Printing Systems

Setup

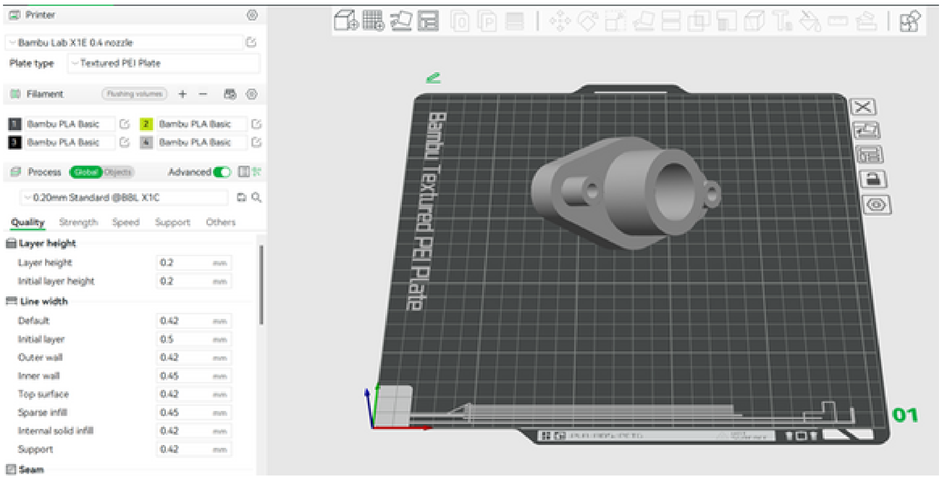


Figure 1.5. Uploading part 2 in Bambu Studio software

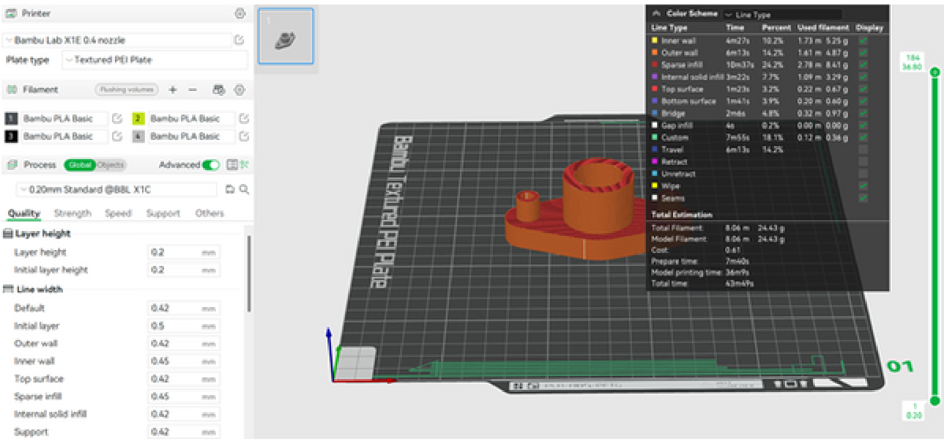


Figure 1.6. Simulation result of part 2

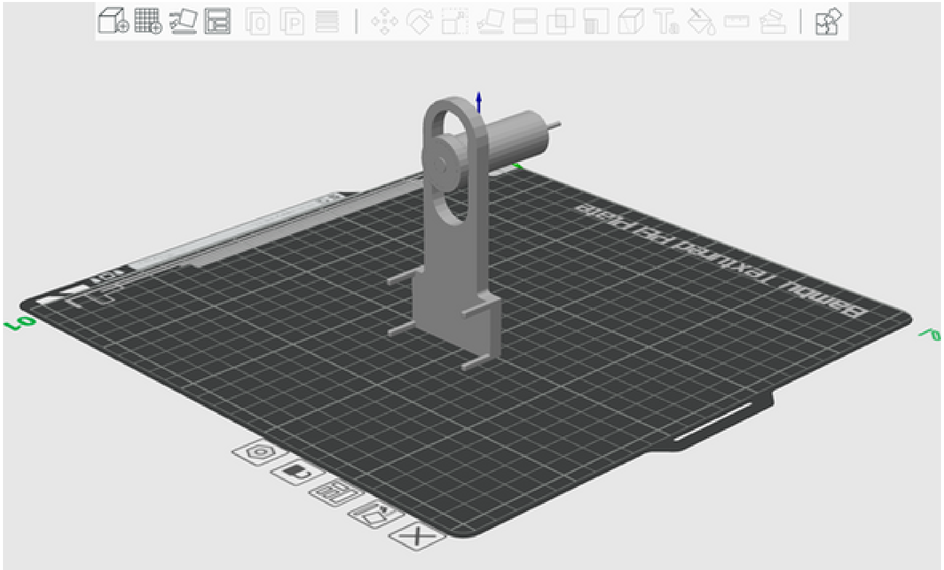


Figure 1.7. Scale factor applied to the distance sensor

Requirements

Handling geometries and scales, and basic knowledge of slicer software.

Learning Outcomes acquired

S1.2 To properly prepare and set up at least 1 additive manufacturing system.
S1.3 To properly operate basic tasks using at least 1 additive manufacturing system.

Duration of the lesson

8 hours

Activities and steps to be implemented

Through the use of the Bambu Studio slicer application, various methods of optimization in time and material for 3D printing will be explored, as well as the correct orientation of pieces and the use of scale factors to achieve the required size. In summary, the concepts covered in this lesson are:

- Optimization of printing parameters.
- Use of support types for printing based on piece geometry.
- Orientation and positioning of pieces for better support with the bed.
- Change scale factors.

Figure 1.5 shows one of the provided parts converted to STL format and uploaded into the Bambu Studio slicer application. The objective of this lesson is to simulate different impressions of the part, focusing on the stability of the part according to the base support and optimizing the time. Several techniques will be used in order to finally obtain the simulation of the part shown in Figure 1.6. For this purpose, the following activities will be carried out:

1. Add and test the different types of parts supports. Load part 2 into the Bambu Studio software. When slicing the part, it is observed that it does not have enough contact with the heated bed (base) to provide stability. A normal manual support or tree-type support will be added, and by slicing the part again, the time spent in the printing simulation will be observed.

2. Optimization of the printing through rotations. The goal of this activity is to place part 2 in an orientation that provides the best possible stability with the printer's base by rotating it. For this purpose, the rotate tool in the prepare section must be used. A significant reduction in printing time and material usage will be appreciated compared to the previous activity, as seen in Figure 1.6.

3. Adjustment of printing parameters. Slice the part with different layer height values (0.1, 0.2, and 0.4 mm) and line width (0.3, 0.42, and 0.7 mm) and deduce the relationship between printing time and detail quality in the part when increasing and decreasing these values. To do this, enable the advanced option in the prepare section of Bambu Studio.
4.Perform the previous activities with part number 3.

Scale change. Load design numbers 4 and 5, consisting of a distance sensor and a holder for that sensor. The scale factor applied to the distance sensor will be obtained so that the sensor fits into the holder, considering the width of holder cavity. To find the scale factor use the measure tool. This factor will then be entered into the scale tool, keeping the uniform scale option active, resulting in Figure 1.7

Module - Robot machines technician for Industry 4.0

Learning Outcomes covered

- K10.1 To describe robot components, characteristics and applicatios
- K10.2 To present what advanced and collaborative robots are and how they work
- K10.3 To list Advantages and disadvantages of collaborative robotics
- K10.4 To list types of collaborative robots (collaborative, Anthropomorphic Systems, Cobots, etc....)
- K10.5 To present differences between collaborative robots and industrial robots
- K10.6 To describe maintenance indicators and diagnostic techniques

Skills

- S10.1 To be able to program a robotic arm to do basic tasks
- S10.2 To setup and monitor an industrial robotic arm
- S10.3 To be able to detect risks and safety problems while a robot is running
- S10.4 To do basic maintenance operations

Lesson 1 - Simulation environment

Setup

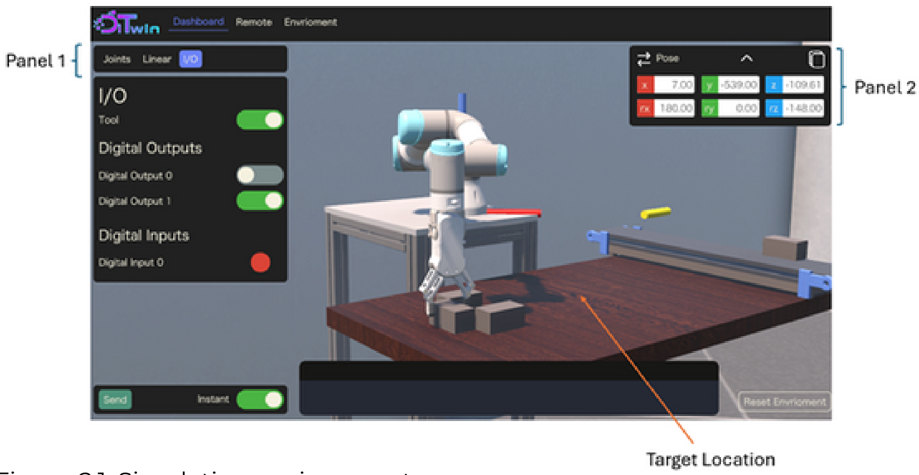


Figure 2.1. Simulation environment.

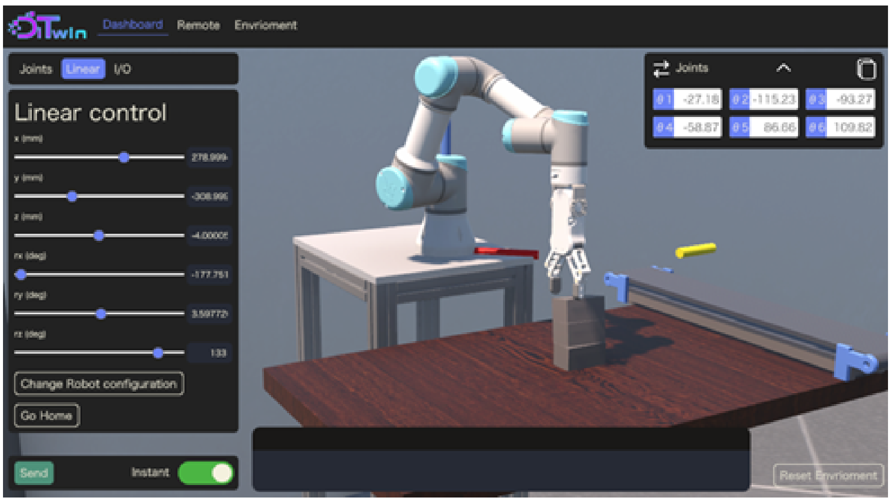


Figure 2.2. Final result of the lesson

Requirements

General knowledge of computer applications and basic notions of robotic systems.

Learning Outcomes acquired

S10.2 To setup and monitor an industrial robotic arm

Duration of the lesson

8 hours

Activities and steps to be implemented

Learn how to configure and operate a robotic system using a digital twin of a UR3e manipulator. The different options of this digital twin will be studied and concepts such as:

- differences between articular and cartesian movement of the manipulator;
- joint position and cartesian pose of the end-effector;
- guided acquisition of manipulator locations;
- manipulator configurations;
- gripping and releasing of parts with the gripper;

Figure 2.1 shows the UR3e robot manipulator in a work environment consisting of a worktable on which three small parts are placed. These three parts have to be moved to a pose specified as TARGET in that figure, where they have to be arranged in the form of a tower as shown in Figure 2.2.

To do this, carry out the following activities:

1. To learn the use of the simulation tool. Free movements of the manipulator will be carried out in order to know the different panels and options provided by the simulator. Special attention will be paid to panel 1 which incorporates the tabs: Joints, Linear and I/O. Additionally, it is possible to change the point of view of the camera within the virtual environment, using the mouse, to obtain different perspectives of the working environment.

2. Move the end effector, with the gripper open, to a location that allows the piece A to be picked up. To do this, approach it by means of joint movements (joint tab in the panel 1) and refine this pose by means of Cartesian movements (Linear tab in panel 1). In order to be able to hold the part properly, the z-axis of the part must be aligned with the z-axis of the table, for which purpose the orientation y of the end effector must adopt the values . The aim of this activity is to understand the differences between articular and cartesian movement, as well as the articular position and cartesian pose of the end effector.

3. Test the different manipulator configurations and select the ones where this point is reachable (LEFTY/RIGHTY, ABOVE/BELOW, FLIP/NOFLIP). This pose must be copied to the clipboard using the copy option in panel 2 shown in figure 2.1. This location can then be saved to a file for later use in a robot program.

4. Close the gripper and pick up the part to move it to the TARGET pose. This location should also be copied to the clipboard and saved to a file for later use in a robot program.
The process shall be repeated for the other two parts (B and C) in order to assemble the tower shown in figure 2.2.

Lesson 2 - Basic programming

Setup

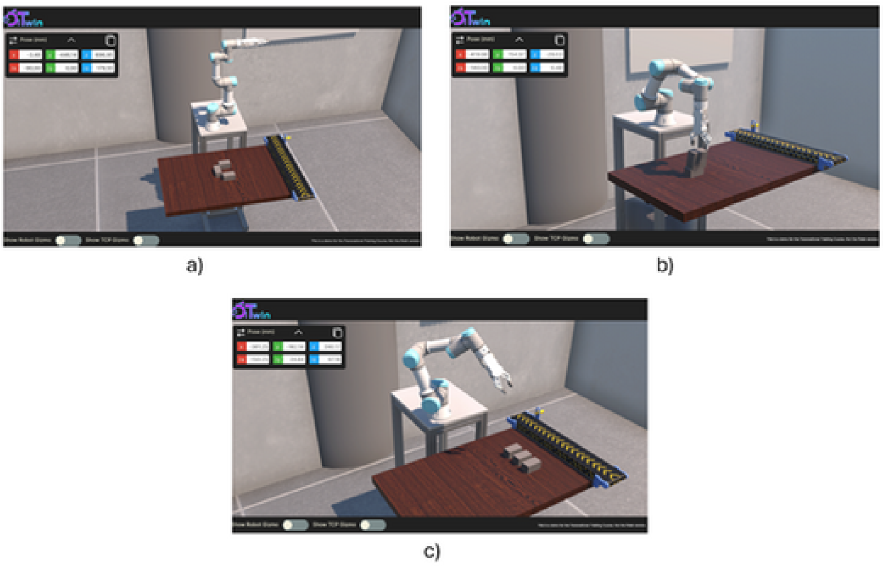


Figure 2.3.(a) Starting position (b and c) Final result exercises

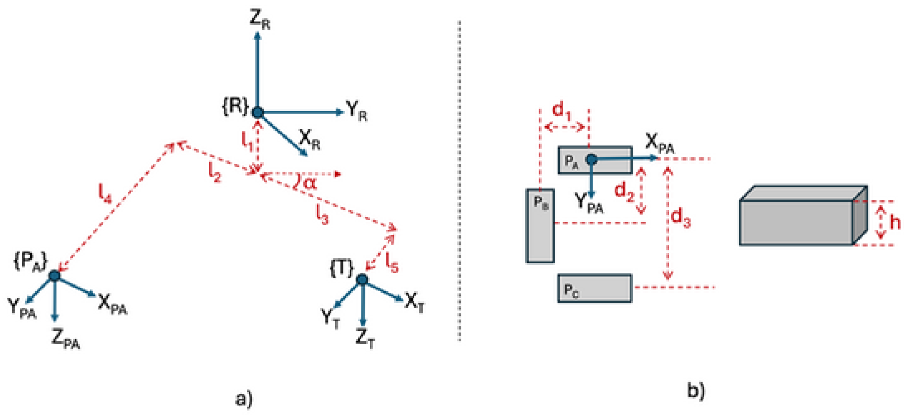


Figure 2.4. Geometrical model of the task

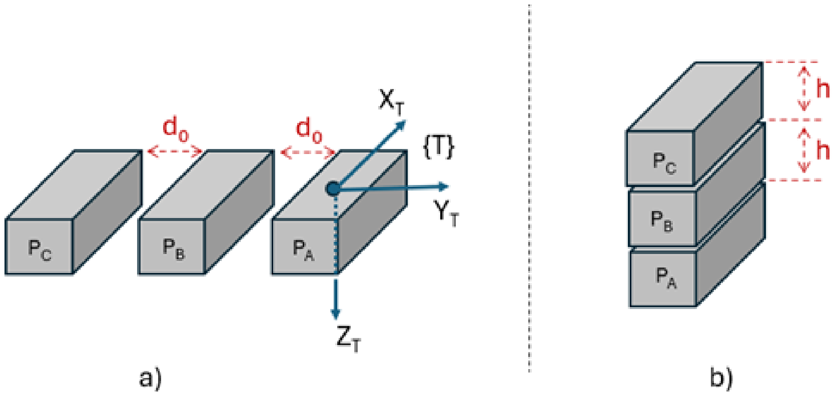


Figure 2.5. Final disposition of Lesson 2, exercise 3 (a) and 4 (b)

Requirements

Knowledge of general-purpose programming languages.

Learning Outcomes acquired

S10.1 To be able to program a robotic arm to do basic tasks.

Duration of the lesson

8 hours

Activities and steps to be implemented

Using the digital twin of a UR3e robot, the basic movement commands of the manipulator will be illustrated, as well as the handling of the gripper, through textual programming. For this purpose, a basic pick and place task will be carried out, which consists of moving several pieces in order to build a tower.

The aspects to be addressed in practice are as follows:

- Manipulator configurations.
- Guided acquisition of manipulator locations.
- Textual programming of basic tasks through basic manipulator movement commands.
- Basic transformations of poses.
- Instructions to manipulate parts with the gripper.

Figure 2.3.a shows the UR3e robot manipulator in a work environment consisting of a worktable on which three small parts are placed. These parts will be moved one by one using the robotic arm to a second area of the table as shown in figure 2.3.b and 2.3.c.

Thus, the following activities must be carried out:

1. Define in the robot language the geometric model of the task, which is detailed in Figure 2.4 and consists of the initial pose of the part A defined by the coordinate system and the target location, defined by the coordinate system . For this purpose, knowing that both are referenced to the coordinate system associated with the robot base , program with the TRANS() function the initial location and the destination location .
2. Find the configuration of the robot in which and {T} are reachable by the commands LEFTY/RIGHTY, ABOVE/BELOW, FLIP/ NOFLIP.
3. Carry out the palletising programme, which consists of moving the three pieces from their initial position to the destination. They have to be aligned and separated from each other, as shown in figure 2.5.a. At the end of the task, the manipulator must be located in a rest position, which is given by a value of their joints of .
4. Repeat the previous exercise, if this time the pieces must be placed stacked on top of each other at the target location, as shown in figure 2.5.b and picture 2.3.a.

Once the correct functioning of the programmes in the digital twin has been verified, access will be requested so that it can be verified in the real physical system.

Lesson 3 - Obstacle avoidance and sensors and actuators programming

Setup

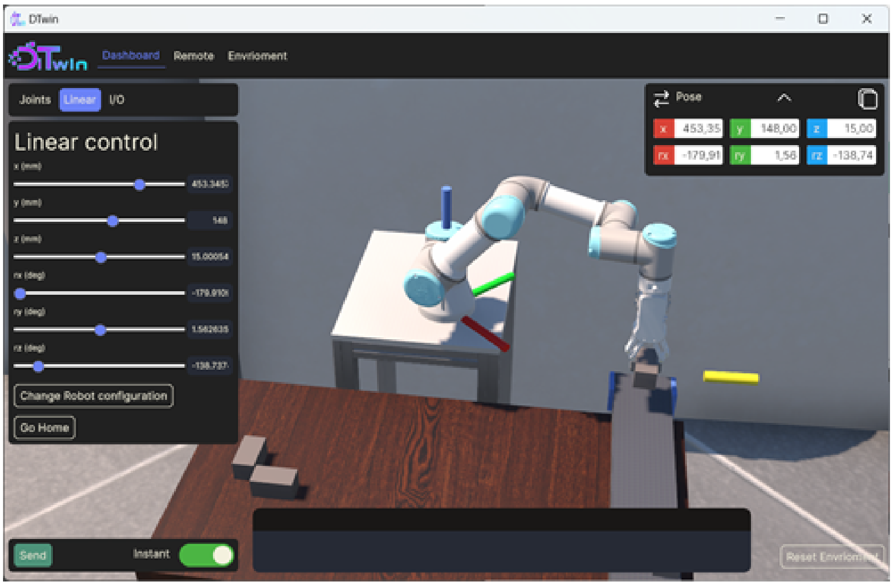


Figure 2.6. Pick up point on the conveyor belt.

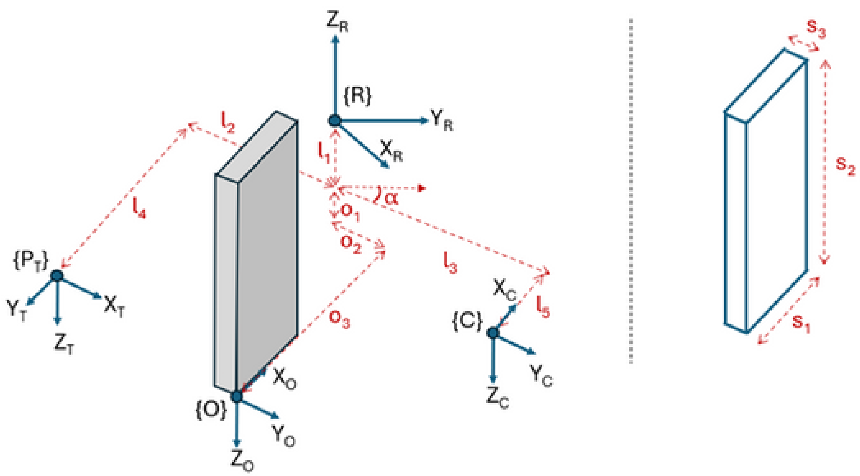


Figure 2.7. Geometrical model of the task

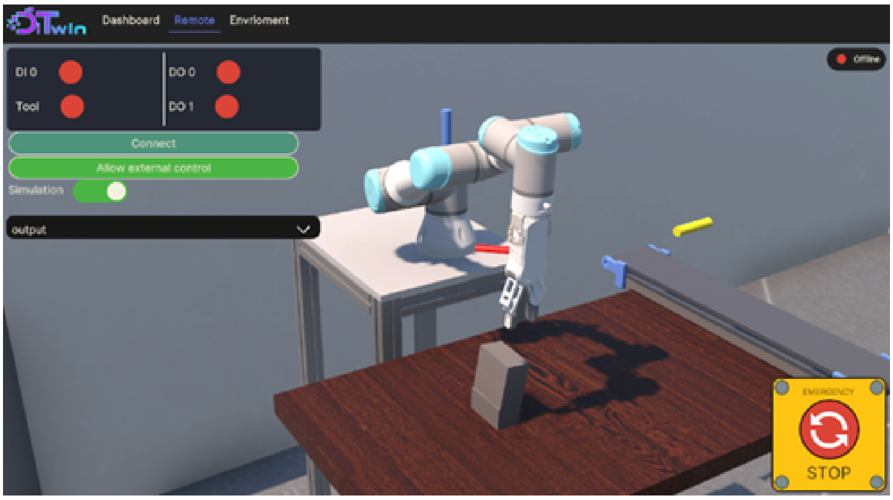


Figure 2.8. Final disposition without obstacle

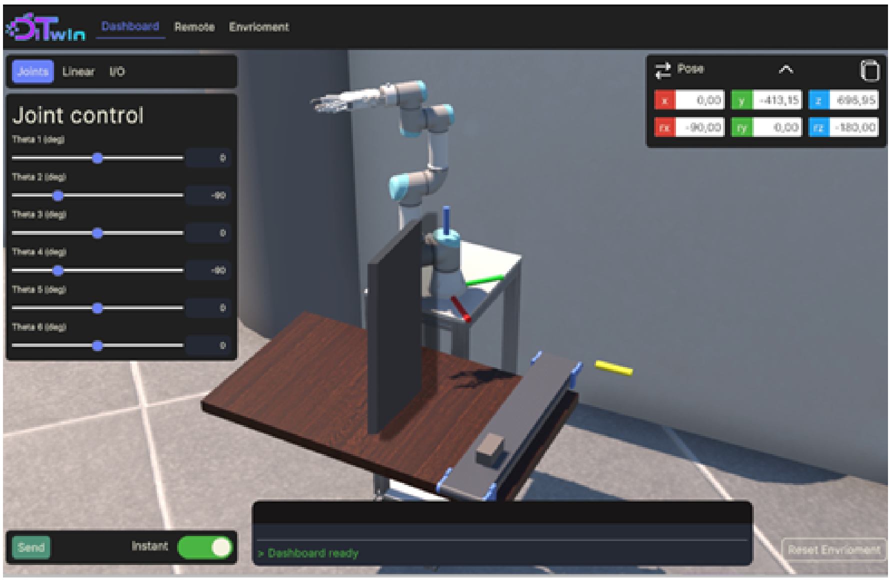


Figure 2.9. Final disposition with obstacle.

Requirements

Knowledge of general-purpose programming languages.

Learning Outcomes acquired

S10.1 To be able to program a robotic arm to do basic tasks.
S10.2 To setup and monitor an industrial robotic arm.
S10.3 To be able to detect risks and safety problems while a robot is running.

Duration of the lesson

8 hours

Activities and steps to be implemented

Using the digital twin of a UR3e robot, it will be shown how digital input and output signals connected to the manipulator can be used to activate actuators and read sensor data.

Furthermore, obstacle avoidance will be considered through the modification of the manipulator's trajectory, either by means of the different configurations of its kinematic model, or changing the trajectory by means of intermediate waypoints to avoid collisions. In summary, the concepts considered in this lesson are the following:

- Manipulator configurations.
- Read and write instructions on Input and Output signals (sensors and actuators).
- Obstacle avoidance through trajectory planning.

Figure 2.6shows the UR3e robot manipulator in a working environment consisting of a conveyor belt on which three small parts are placed, a sensor located on the conveyor belt, which is able to detect the presence of a part on the conveyor belt at the location defined by and, finally, a worktable. These parts will be moved, one by one by means of the use of the robotic arm, to an area of the table, specified as TARGET, which appears in the aforementioned figure.

In order to do so, it must carry out the following activities:

1. Define in the robot language the geometrical model of the task, which is detailed in Figure 2.7 and consists of the pick-up position of the parts on the conveyor belt defined by the coordinate system the destination location, defined by the coordinate system and a possible obstacle at {O}. To do this, knowing that all the locations are referenced to the coordinate system associated with the base of the robot , program with the TRANS() function the pick-up location and the destination location.

2. Find the configuration of the robot in which and are reachable by the commands LEFTY/RIGHTY, ABOVE/BELOW, FLIP/ NOFLIP.

3. Initially, without the presence of the obstacle, modify the palletising programme carried out in the previous lesson in the following way: the picking of parts will be carried out at the location corresponding to the conveyor belt. Thus, the first part of the program, have to activate the belt motor (WRITE command) and wait until the part is detected by the presence sensor (WAIT and READ commands).

4. The obstacle is added to the work environment as shown in figure 2.9. The programme must be modified in order to avoid the obstacle introduced. To do this, it will be necessary to introduce intermediate waypoints in the trajectory and/or choose the appropriate robot configuration (LEFTY/RIGHTY, ABOVE/BELOW, FLIP/ NOFLIP) to avoid the collision.

Once the correct functioning of the programmes in the digital twin has been verified, access will be requested so that it can be verified in the real physical system.

Module - Automation technician for Industry 4.0

Learning Outcomes covered

- K4.1 To understand how automated machines and plants work in industry 4.0
- K4.2 To understand fundamentals of mechatronics
- K4.3 To understand fundamentals of automation and robotics
- K4.4 To be aware of fundamentals of electrical engineering and electronics
- K4.5 To understand the fundamentals of pneumatics and hydraulics
- K4.6 To describe maintenance indicators and diagnostic techniques

Skills

- S4.1 To install basic automated production systems
- S4.2 To monitor the smooth operation of automated production systems
- S4.3 To perform basic repairs on automated production systems
- S4.4 To do basic maintenance operations
- S4.5 To be able to operate a Programmable Logic Controller (PLC)

Lesson 1 - Introducing mechatronics, automated machines and plants work in industry 4.0

Setup 1 and 2

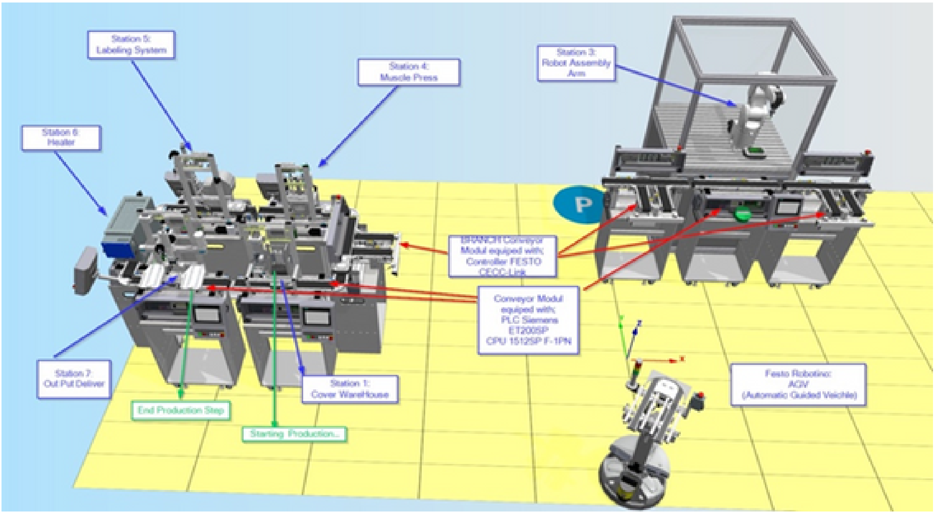
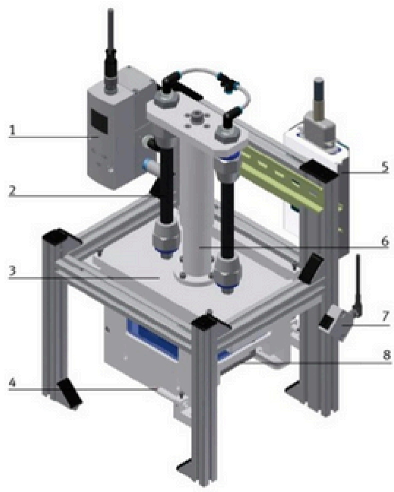


Figure 3.1. Setup 1 - CPC Factory



Position	Designation
1	Proportional pressure control valve
2	Fluid muscle
3	Baseplate press
4	Workpiece request
5	I/O Box
6	Guidance
7	Workpiece request
8	Press plate

Figure 3.2. Setup 2 - Press

Requirements

Basic knowledge of mechanics, electronics and microcontrollers.

Learning Outcomes acquired

K4.1 To understand how automated machines and plants work in industry 4.0
K4.2 To understand fundamentals of mechatronics
K4.3 To understand fundamentals of automation and robotics

Duration of the lesson

8 hours

Activities and steps to be implemented

SETUP 1
Use the Digital Twin to observe the operation of the CP Factory, how the mechanical systems interact through the input signals managed by the microcontroller.

The CP Factory is a professional and compact Industry 4.0 learning system. It includes all the technologies and components needed for communicating an in-depth knowledge of Industry 4.0. The modular and flexible design has a range of learning scenarios, from individual pallet transfer systems with integrated controller right up to a connected production system with cloud services.

In this activity, participants will launch a production order through the Factory Digital Twin and observe the entire process connected to it.

SETUP 2

Use the digital twin to observe the operation of the robotic components in the CP Factory, how they interact with process programming.

In this activity, participants will interact through the Factory's Digital Twin with an automatic component, the press module and its operating parameters, and will observe the device in its operations.

Lesson 2 - Fundamentals of mechatronics, electrical engineering and electronics

Setup 3

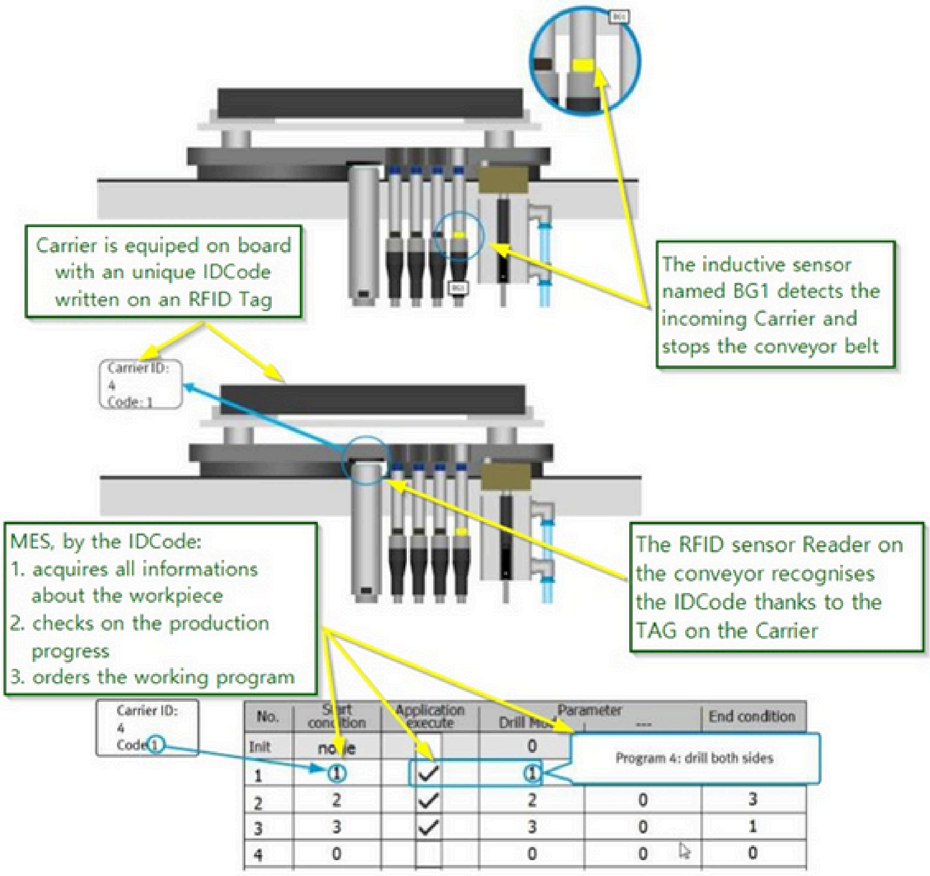


Figure 3.3 Carrier

Requirements

Basic knowledge of mechatronics and electronics

Learning Outcomes acquired

K4.4 To be aware of fundamentals of electrical engineering and electronics

Duration of the lesson

4 hours

Activities and steps to be implemented

Students will be asked to observe and interact with a simulated automated system for industry 4.0, managing some simple operations with the sensors and connections, control systems and electric actuators.

In this activity, participants will interact through the Factory's Digital Twin with a process motion sensor, they will be able to define waiting times, restart events, and observe every single movement of the carrier

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Lesson 3 - Fundamentals of pneumatics and hydraulics

Setup 4

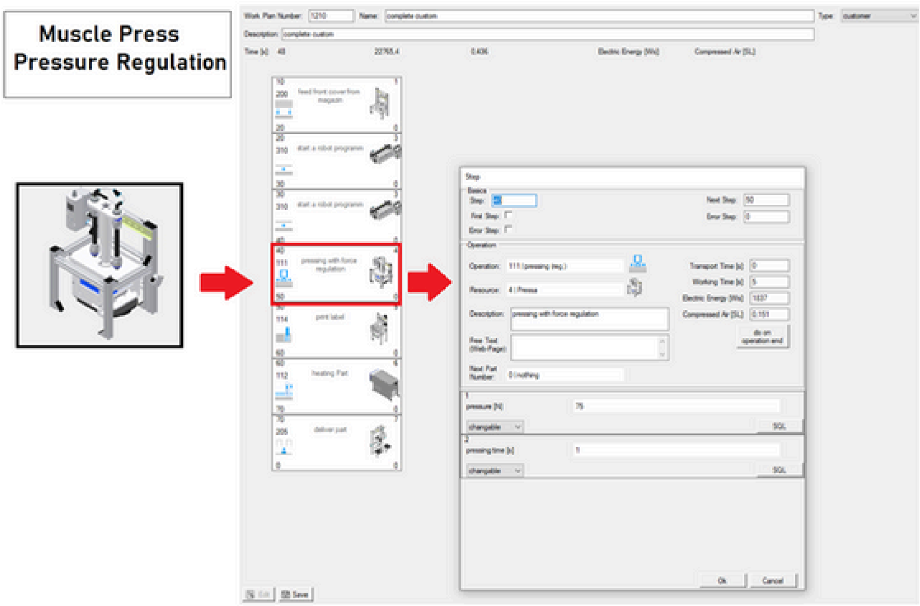

Figure 3.4 Muscle Press

Requirements

Basic knowledge of pneumatics and hydraulics

Learning Outcomes acquired

K4.5 To understand the fundamentals of pneumatics and hydraulics

Duration of the lesson

4 hours

Activities and steps to be implemented

The students will be asked to observe and interact with a simulated automated system for industry 4.0, managing some simple operations with pneumatic and *hydraulic actuators (* only as a software simulation).

In this activity participants will interact through the Factory's Digital Twin by varying the operating pressure parameter of the pneumatic press device and will be able to observe it in action

Lesson 4 - Programmable Logic Controller (PLC), installing and monitoring production systems

Setup 5, 6 and 7

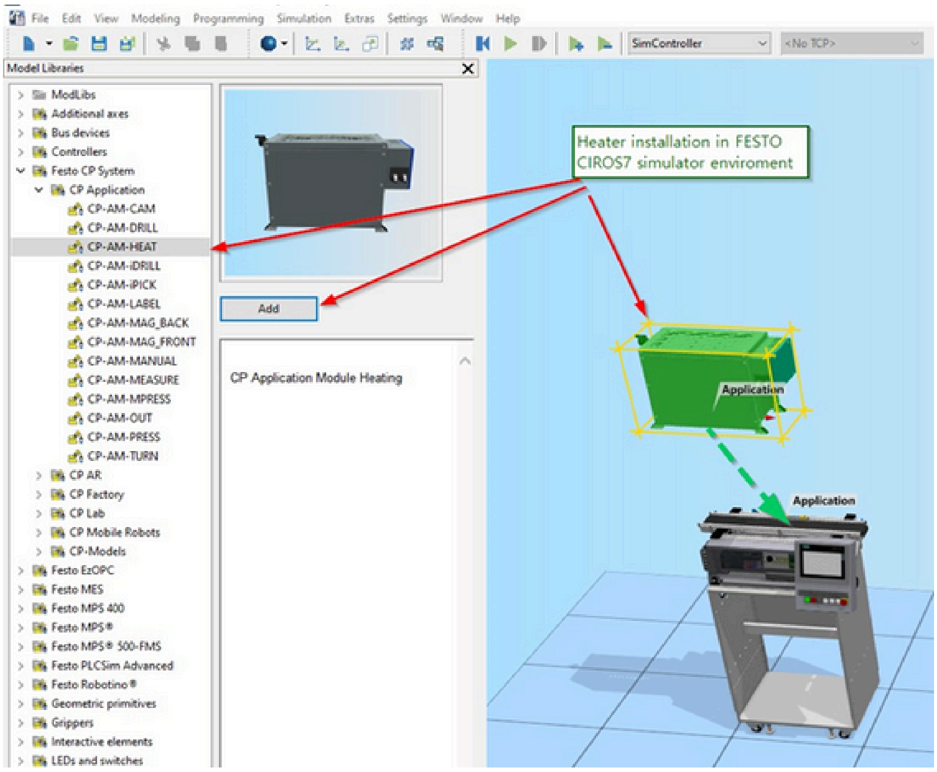

Figure 3.5 - Setup 5 - Component Installation

Figure 3.6 - Setup 6 - Energy parameters

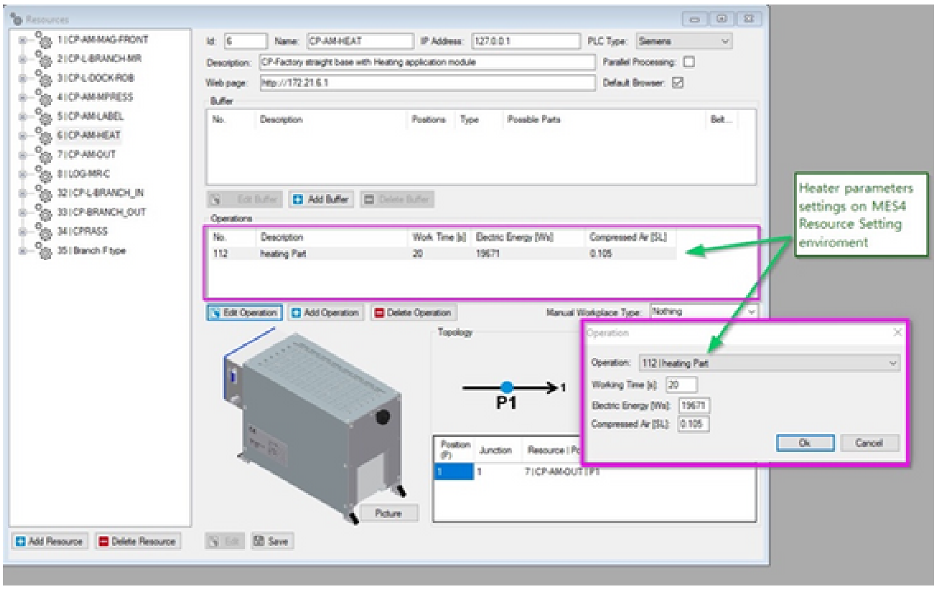

Figure 3.7 - Setup 7 - Factory PLC

Requirements

Basic knowledge of PLC

Learning Outcomes acquired

S4.1 To install basic automated production systems
S4.2 To monitor the smooth operation of automated production systems
S4.5 To be able to operate a Programmable Logic Controller (PLC)

Duration of the lesson

12 hours

Activities and steps to be implemented

SETUP 5

agree on a remote installation of a new device within the automated system, reprogram the Digital Twin and observe process changes
In this activity, participants will be able to add new components to the CP Factory by drawing on the system libraries.

The exercise involves the use of the Digital Twin to install an industrial heating oven within the Factory's production process. Participants will be able to observe how the production system increases its functionality and how the various Factory components integrate with each other.

SETUP 6

Use the Digital Twin to monitor the progress of processes in simulated automated system for industry 4.0. Check the energy parameters of the system, the functioning of the modules and any anomalies also in a predictive maintenance logic.

In this activity, participants will be able to monitor the CP Factory by measuring the consumption of electrical energy and compressed air, as well as other variables such as currents, voltages, active and reactive power. These parameters will also allow for an anomaly analysis and predictive maintenance of the installed components.

SETUP 7

Use the Digital Twin to make simple changes to the PLC systems, manage some simple operations by changing programming parameters and observing what happens.

In this activity, participants will interact with a Factory PLC through the Digital Twin by programming the temperature and duration parameter of the previously installed oven heater device and will be able to observe it in action.

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Conclusions

The DiTwin Modules represent a strategic innovation in vocational education, seamlessly integrating digital twin technologies into VET curricula to meet the evolving competencies demanded by Industry 4.0. By simulating industrial processes and providing hands-on experiences that bridge theoretical learning and practical application, the modules address skill gaps often encountered in traditional educational settings and support the transition of VET students into the workforce.

As a result, VET institutions are better positioned to deliver up-to-date, industry-relevant training—strengthening their capacity to produce highly skilled graduates who are prepared to thrive in modern manufacturing, robotics, and other high-tech domains. The adaptability of the DiTwin Modules ensures that they can be used alongside conventional classroom teaching, enabling educators to easily incorporate cutting-edge digital simulations into their lesson plans.

Moreover, the significance of the DiTwin Modules extends beyond the classroom, offering opportunities for collaboration and engagement among a broad range of stakeholders—companies, policy makers, industry associations, and other educational organizations. By fostering these connections, the modules contribute to more coherent and responsive VET ecosystems, helping to prevent youth unemployment and addressing emerging labor market needs.

In essence, the DiTwin Modules catalyze a forward-thinking approach in vocational education, ensuring that both learners and institutions remain well-equipped to meet the challenges and opportunities presented by Industry 4.0.

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Project Number: 2023-1-IT01-KA220-VET-000154611

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