

MPS 400 Learning Factories

The new all-around learning system
for automation technology

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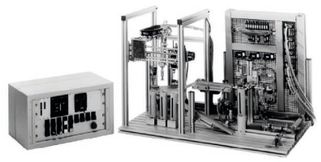
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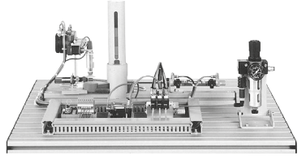
56865 08/2021 Festo Didactic SE

MPS

The Modular Production System

A standard learning system for mechatronics engineering









The origins of the mechatronics engineer

1988

The term “mechatronics” was coined in the 1960s by senior engineer Tetsura Mori, who worked for the Japanese company, Yaskawa Electric Corporation. Since then, the field of mechatronics has grown out of robotics innovation, specifically, advancements in programming, sensor technology and controls. It has evolved from an increasing overlap of competencies in the fields of mechanical engineering, electrical engineering and information technology, requiring the emergence of new cross-sectional functions. Thus, the job profile of the mechatronics engineer was born.

The learning system for mechatronics engineers

1989

The reorganization of the metalworking and electrical professions in Germany around 1988 and their implementation in company training practice necessitated a new training approach for the merging of the professions. Based on today’s competitive requirements, Festo developed a comprehensive learning system for practice-oriented training that develops the necessary skills to become a mechatronics engineer.

MPS Release A

1994

A new era of modularity
“With MPS Release A, four individual stations were created from one system that combined the process steps of distributing, checking, processing and storing.”

Dr. Theodoros Ktistakis
Product Manager
from 1989 to 1993

MPS Release B

1997

More compact than ever
“The new MPS stations of the B Release became much more compact than their predecessors and mapped more diverse process steps. In addition, they could now be used independently of other stations.”

Werner Reichelt
Product Manager
from 1993 to 1998

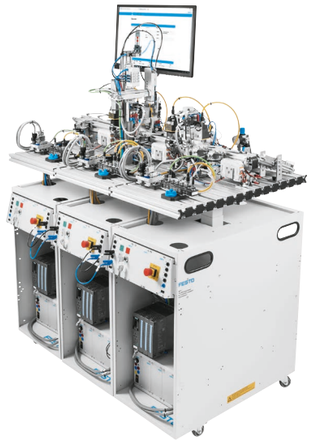
MPS Release C

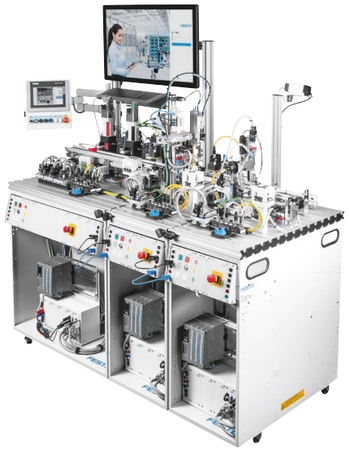
2002

Progress in communication
“The C release brought improved communication via one bit and a simplified control panel. In addition, workpieces could now be identified at each station and the integration of the Robotino became possible.”

Eckhard von Terzi
Product Manager
from 1998 to 2005







MPS Release D

2014

Focus on flexibility
“The D release has enabled even greater modularity within the stations. Furthermore, the creation of new process lines became even more flexible. In addition, suitable MPS teaching and learning materials were created.”

Michael Linn
Product Manager
from 2005 to 2016

MPS 203 I4.0

2017

First steps towards Industry 4.0
“With the MPS 203 I4.0, the MPS got up close and personal with the topic of Industry 4.0 for the first time. This was made possible by the integration of a digital product memory based on RFID – a basic technology of Industry 4.0.”

Alexander Abdo
Product Manager
since 2016

MPS 403-1

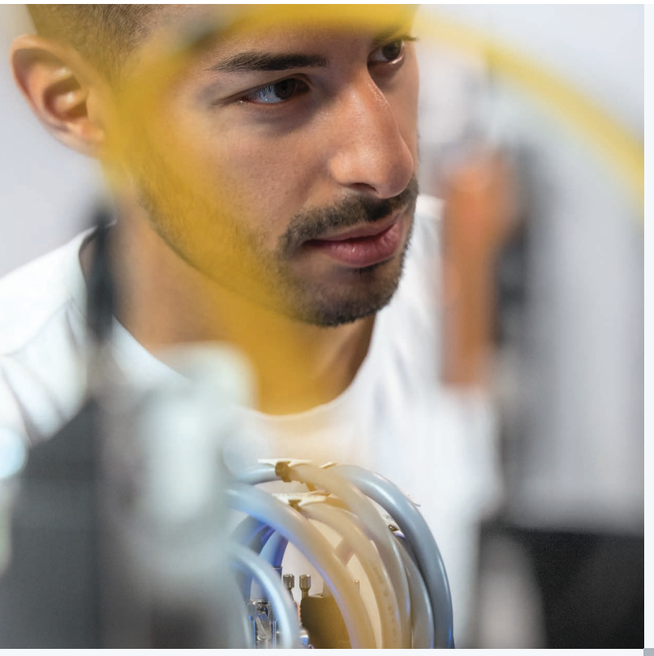
2020

A true all-rounder
“For the first time in MPS history, the learning system covers the entire spectrum from the basics of mechatronics and automation to state-of-the-art, software-intensive Industry 4.0 content. A rounding out of the content of the range of topics in all directions.”

Alexander Abdo
Product Manager
since 2016



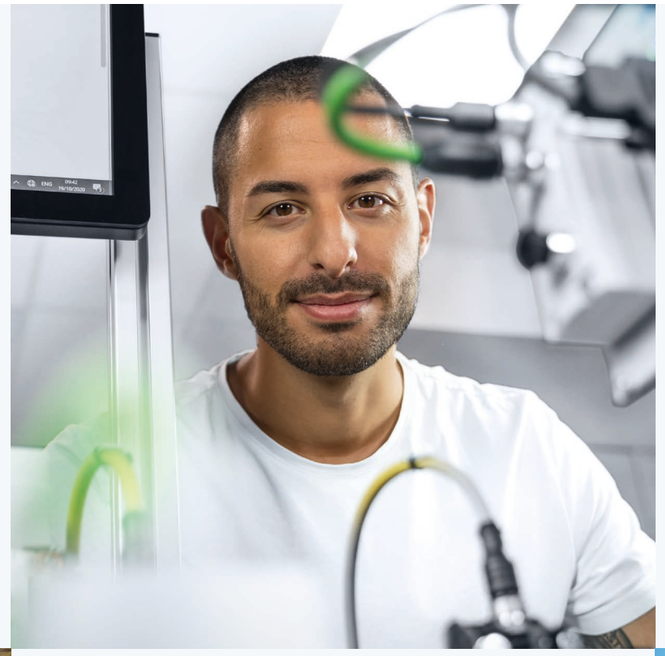
Table of contents



02

MPS 400
The new all-around series

Page 08



04

MPS 400
Additional packages

Page 44

01

MPS – The Modular Production System

Page 04



03

MPS 403-1
Subject areas

Page 18



01 | MPS – The Modular Production System

Photo: courtesy of WorldSkills International

The MPS – a success story

A standard from the beginning

Taking the form of a miniaturized production line, the MPS offers an in-depth look into intelligent networking of machines in the production environment, and their work processes. Individual functions of the production or assembly process are grouped into modules from which entire work stations can be accessed in mechatronic units. Each module offers different learning focuses. The modular character of the MPS system enables a flexible and extensive offering of mechatronics and Industry 4.0 learning content.

Real industrial processes are the basis for our MPS learning system. Only high-quality industrial components are used that can withstand the rough and tumble of everyday laboratory life.

Excellence through WorldSkills

Through Festo's involvement in WorldSkills and interdisciplinary collaboration with experts and users worldwide, we have continuously developed the MPS to set the industry standard for hands-on industrial training.

The effectiveness of the learning system was recognized worldwide in 1991 when MPS became the official platform for the WorldSkills' competitions in the field of mechatronics.

In this competition, an increasing number of teams from different nations compete every two years to crown the best mechatronics technicians in the world. In doing so, the MPS has to meet the high technical and physical demands of the world's best. For this, the MPS received the Worlddidac Award in 1998.

At the forefront of innovation

Today's world is driven by constant innovation. Our dedicated focus on the didactic preparation of career training programs and topics has evolved into complete learning systems that accurately reflect the state of the industry, while creating pathways to new technologies and innovation for learners.

The modern MPS

Today, the modern MPS covers a variety of topics across the mechatronics and Industry 4.0 spectrum, reaching students at various levels and skill sets.



"I am convinced that with the MPS we have created a really incredibly future-proof learning system. The use of MPS at Siemens in the SMSCP, as well as at WorldSkills as a platform for the vocational competitions in mechatronics and automation technology speaks volumes."

Michael Linn
Product Manager from 2005 to 2016
Current Skills Competition Manager

02 | MPS 400
The new all-around series



MPS 400 – the new all-around series

A learning system for everyone

The MPS 400 series is the latest product line from Festo's MPS family. MPS 400 makes it easy to assemble individual learning factories that cover a wide variety of curricula and training requirements for different industries and job roles.

Benefits for learners

- Learners receive extensive training using a uniform learning system.
- Learners are guided through the complete curriculum step-by-step, exercise-by-exercise.
- Learning content is comprehensive, from the basics to very complex topics.
- Modular hardware creates flexible experiential learning.
- Industry-proven components and technologies increase employability after completion of the training.
- Adjustable trolley heights ensure an ergonomic and low-fatigue work environment.

Benefits for teachers

- The step-by-step course materials enable learners to work independently most of the time.
- Teachers can be confident that the system will function reliably for many years thanks to high-quality components.
- The expandability of the learning system and the space-saving design ensure an overall cost-efficient solution.

Benefits for innovators

- The learning system covers a wide range of modern Industry 4.0 content and as well as fundamentals of mechatronics and automation technology.
- MPS 400 offers introductory insights into artificial intelligence and machine learning algorithms.
- Digital courseware compatible with the MES and accompanying software.



"I am particularly proud of having, together with a strong team, significantly pushed the MPS Release B with all the new stations and learning content towards modularity and mobility. We were rewarded for this with the gold Worlddidac Award in May 1998."

Werner Reichelt
Werner Reichelt, Product Manager from 1993 to 1998
Currently Business Development

MPS 400 System building blocks at a glance

Modular hardware
An MPS 400 system building block is an MPS station built on a trolley with lifting function, containing all elements for seamless integration into a learning factory, which might consist of several system building blocks. Each system module represents a process step that is modelled on real-world production. The trolley is equipped with a control panel that contains buttons for basic controls and signals the status of the station by means of three lights. An emergency stop button stops all actuators within the system module. Some of the input and output signals as well as 24 V and GND can be tapped at 4mm safety lab sockets on the left and right of the control panel. Thanks to the lifting function, the working height can be ergonomically adjusted.

Industry 4.0 right from the start
The system building blocks are equipped with an Ethernet switch and PLC. The PLC program connects the system module with the MES and the entire plant. An RFID read/write head is connected to the PLC via an RFID controller. This can read and write the digital product memory in RFID tags of individual workpieces.

Vertical integration
The required production steps (with individual parameters if needed) can be transferred individually for each workpiece from the MES to the PLC of the system building block. This teaches the learner concepts such as variant diversity in production up to batch size 1.

MPS 400 Distribution Pro

Industrial HMI and smart sensors



The MPS 400 Distribution Pro system building block pushes workpieces from three stacking magazines individually onto the conveyor belt using double-acting cylinders.

Learning topics

- Fundamentals of mechatronic sub-systems/complete systems
- Digital sensors and actuators
- Intelligent sensors with IO-Link
- Object identification with RFID
- Visualisation with HMI
- Plant control with MES
- Programming and graphic representation of simple control sequences
- Data protection and security
- Commissioning and troubleshooting
- Recycling and economic aspects

MPS 400 Joining

Industrial Ethernet, vacuum and parallel gripper technology



The MPS 400 Joining system building block checks the position of the workpieces with a laser sensor and mounts various attachments if the position is correct.

Learning topics

- Fundamentals of mechatronic sub-systems/complete systems
- Optical sensors and actuators
- Machine safety and occupational health and safety
- Pneumatics and vacuum technology
- Intelligent maintenance with AR
- Condition monitoring
- Industrial communication with OPC-UA and PROFINET
- Programming and graphic representation of simple control sequences
- Commissioning and troubleshooting
- Energy efficiency and environmental protection

MPS 400 Measuring Pro

Industrial measurement technology and analogue value processing



The MPS 400 Measuring Pro system building block measures height and fill level as well as the weight of the workpieces. Defective parts are ejected on a chute.

Learning topics

- Basics of mechatronic sub-systems/total systems
- Tactile sensors
- Pneumatics and electropneumatics
- Measurement technology with strain gauges and measurement amplifiers
- Data acquisition and quality assurance
- Statistical process control (SPC)
- Production transparency and operating cost reduction

MPS 400 Sorting Inline

IIOT retrofitting and machine learning



The MPS 400 Sorting Inline system building block sorts the workpieces according to detected color and material or passes them on in the process.

Learning topics

- Basics of mechatronic sub-systems/complete systems
- PLC programming advanced
- PLC programming in the context of I4.0 (HMI I RFID)
- Artificial intelligence (AI/ML)
- New business models through retrofitting (IoT)
- Data and information security
- Commissioning troubleshooting strategies
- Ecological and economic

MPS 400 Robotino

Flexible manufacturing through mobile robotics



The MPS 400 Robotino system building block grips workpieces with a parallel gripper and transports them from one MPS 400 system building block to the next.

Learning topics

- Analyzing electronic systems and testing functions
- Analyzing and adapting controls
- Programming and implementing controls according to IEC 61131
- Getting to know the omnidirectional drive concept
- Integrating control and communication systems
- Mapping and autonomous navigation
- Motor control

Further system building blocks will follow ...

Sample configurations of the MPS 400 series

From the system building block to the modular system
The MPS 400 system building blocks can be flexibly combined into different systems with different learning focuses. This allows the learning systems to be individually adapted to the corresponding environment depending on the desired learning content, available space and budget. Further system building blocks and additional packages can be added later.

MPS 400 Distribution Pro	MPS 400 Joining	MPS 400 Measuring Pro	MPS 400 Sorting Inline	MPS 400 Robotino (optional)

The systems in detail

Recommended additional packages

MPS 401-1



MPS 400 Distribution Pro – Central infrastructure for all systems
The MPS 400 system module Distribution Pro forms the basis for all MPS 400 systems. It offers the necessary IT and software infrastructure with FactoryViews (p. 22) including an MES4lite licence, with which up to four system building blocks can be integrated into a system free of charge. Many basic topics can already be trained on this system module. In addition, it provides deep insights into intelligent sensors and modern human-machine communication.

IT security	Machine safety	Energy monitoring
◐	○	○

MPS 402-1 or MPS 402-1 R







MPS 402-1 – Small but mighty
Our most compact learning factory reproduces a complete production process. Here, workpieces are distributed and picked onto different chutes after a short quality check. MPS 402-1 is the ideal entry into the world of Industry 4.0 for smaller budgets and addresses topics such as artificial intelligence and IoT in production.
Extensions: Through the optional integration of Robotino, the MPS 402-1 can be transformed into an **MPS 402-1 R**. Robotino forms the bridge between the system building block Distribution Pro and the system building block Sorting Inline.

IT security	Machine safety	Energy monitoring
●	○	◑

MPS 403-1 or MPS 403-1 R









MPS 403-1 – Learning from a value-added production process
In the MPS, great importance has always been placed on practical application. In addition to the use of real industrial components, a value-added production process is an important building block for creating a learning system that is as close to practice as possible. MPS 403-1 is a reliable, all-around learning system that covers most basic topics in the field of mechatronics and Industry 4.0.
Extensions: In addition to the optional Robotino integration **MPS 403-1 R**, MPS 403-1 can be supplemented with various expansion packages. In this way, current topics such as IT security, energy monitoring and machine safety can be configured as required or added at a later date.

IT security	Machine safety	Energy monitoring
●	●	●

MPS 404-1 or MPS 404-1 R











MPS 404-1 – Complete manufacturing in a learning format
MPS 404-1 offers all the basic aspects of complete, automated production. The value-added production process of the MPS 403-1 is supplemented by solid industrial measurement technology for quality control. A pneumatic valve terminal controlled via IO-Link for controlling a rotary-stroke unit also deepens the electro-pneumatic learning content in the direction of digitalization.
Extensions: MPS 404-1 can also be optionally supplemented with Robotino (**MPS 404-1 R**) and expanded with various learning packs.

IT security	Machine safety	Energy monitoring
●	●	●

Process steps on the MPS 403-1



01

MPS 400 Distribution Pro

The first station distributes the workpieces – round jars in different colors – from 3 different stacking magazines. The digital product memory on the RFID tag in the workpiece is initialized.

02

MPS 400 Joining

The process task of the second station is joining. Here, either a normal lid or a small micro-controller can be joined to the workpiece. To mount the microcontroller, the vacuum gripper of the Pick&Place unit is exchanged for a parallel gripper. Both grippers are included in the system.

03

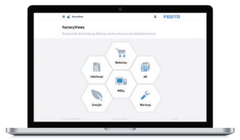
MPS 400 Sorting Inline

In the third station, the color and material of the workpieces are detected with the help of different sensors. They are then sorted on two chutes or passed onto a subsequent station. An AI/ML-based algorithm monitors the two chutes with the help of a camera and triggers notifications depending on the available capacity.

03 | MPS 403
Subject areas

MPS 403 Subject areas

Our new learning solution for Industry 4.0 and the training of basic skills in the field of mechatronics and automation technology addresses important learning content and technology areas.



FactoryViews
The new software portal with MES and web shop offers central access to all software modules for our learning and research factories.

Page 22



MES4 V3
Our Manufacturing Execution System controls your model factory – from the single station to the complex learning factory or the simulation with CIROS.

Page 25



Web shop
The integration of a web shop illustrates the horizontal integration of software modules in the value chain. Customer-specific product configurations are thus automatically transferred to the machine.

Page 26



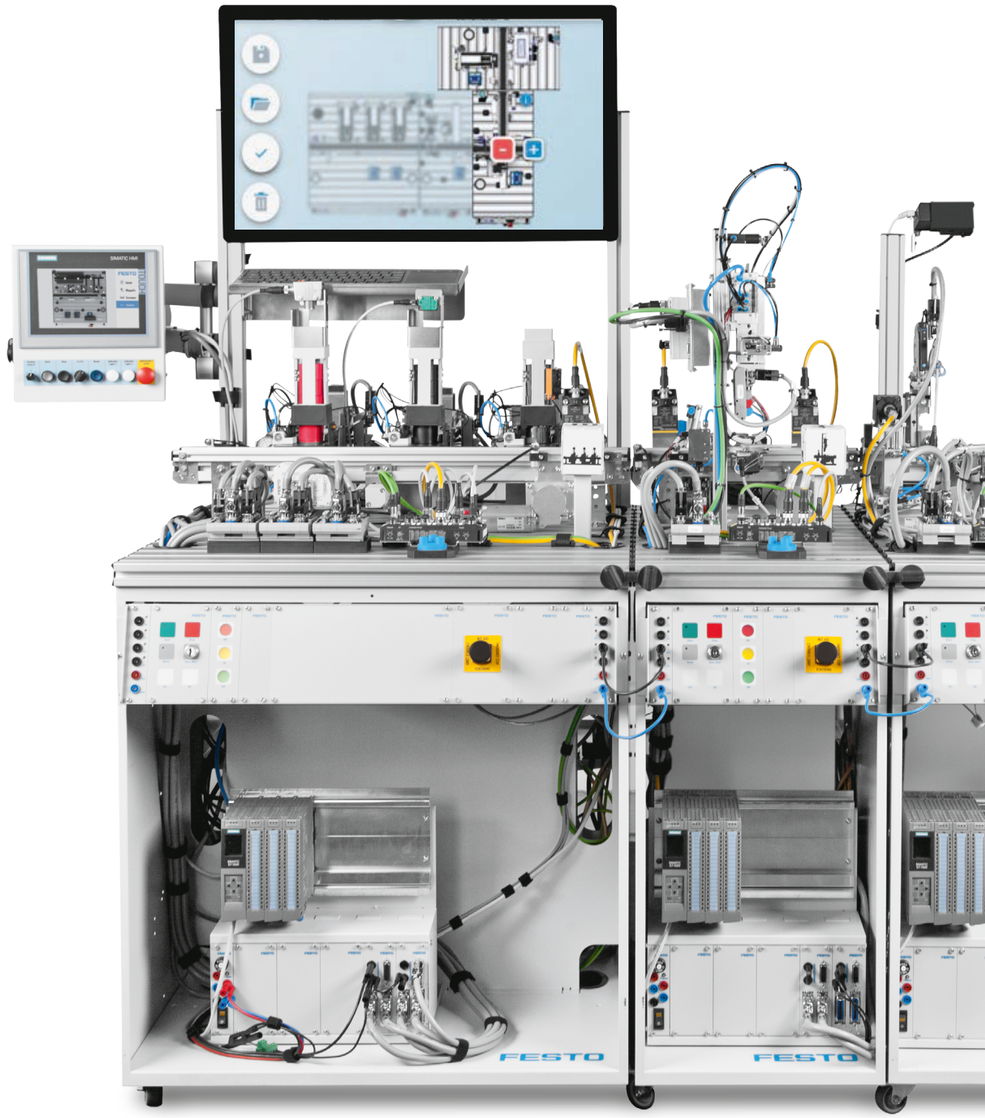
HMI
An industrial touch panel for the visual processing of real-time information serves as a modern human-machine interface, e.g. for the parameterization of smart sensors.

Page 29



Smart sensors with IO-Link
In addition to the actual sensor values, intelligent IO-Link-based sensors provide additional data, such as the degree of contamination, and thus increase reliability and data quality.

Page 30



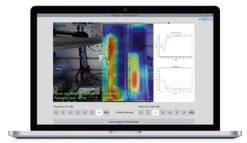
IIOT-Retrofitting
The retrofitting of existing production plants opens up new business models and thus sources of income. Algorithms from artificial intelligence simplify the collection and evaluation of data.

Page 33



Artificial Intelligence and Machine Learning
In the context of Industry 4.0, machine learning offers countless areas of application for the automated analysis of large amounts of data. Learning how to accurately disseminate data in order to adjust factory processes can make the difference for increasing a manufacturer's competitiveness and profit.

Page 34



Augmented Reality
Optical markers enable an augmented reality supported learning process. This means relevant technical information on the learning unit and hardware component can be accessed and worked on more easily and intuitively.

Page 37



Industrial networking with PROFINET
Modern industrial systems consist of many complex networked components with constant data exchange. Technologies such as PROFINET and IO-Link enable the reliable and efficient connection of various components.

Page 38



PLC programming and industrial communication
Highly networked systems and service-oriented architectures require new PLC programming structures. Protocols such as OPC UA facilitate the open exchange of data – even across manufacturers – and are thus forward-looking.

Page 41

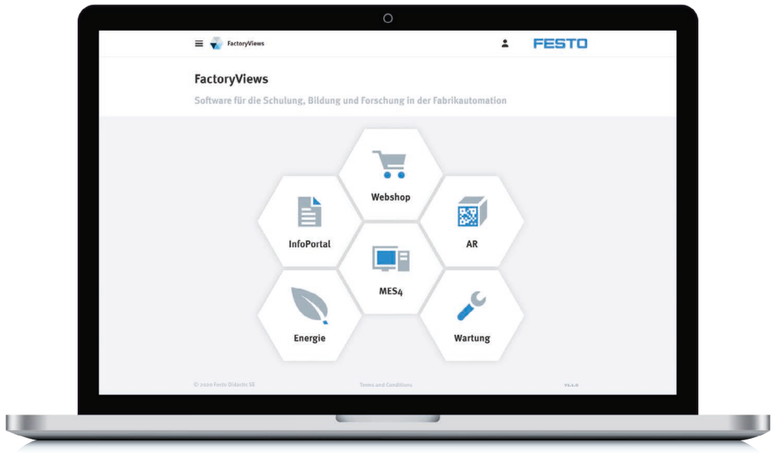


RFID
RFID has already established itself as a basic technology of I4.0. Digital product memories enable customized production processes.

Page 42



FactoryViews



Central software environment
FactoryViews is our new software portal through which learners, researchers and teachers can centrally access all software modules for our learning and research factories in the field of factory automation.

With FactoryViews, the topics of production, mechatronics, automation and Industry 4.0 are optimally covered on the software side.

Versatile applications
The software ecosystem is tailored to meet today's Industry 4.0 education and training requirements. It is the node and anchor point for easy access to MES4, web shop and many other applications that can be individually integrated and configured.

AR App
Explore your learning system in augmented reality with a tablet or smartphone. The AR app intuitively visualizes the structure, the control connection or the steps for commissioning the learning system.

Info Portal
The Festo Info Portal supports learners and educators in using the existing hardware – offline with technical documentation or online with the latest updates.

Comprehensive I.40 education suite
FactoryViews is digitally optimized and optimized for mobile devices and touch operation. This means all information can be accessed regardless of location.

MPS 400 is supplied with FactoryViews and already includes licences for MES4 and the web shop. In addition, the InfoPortal and the AR app can be used without an additional licence.

In the background, all program components such as the web server, database server and email server work hand in hand. The interfaces of the applications are open and can also be used via external programs.

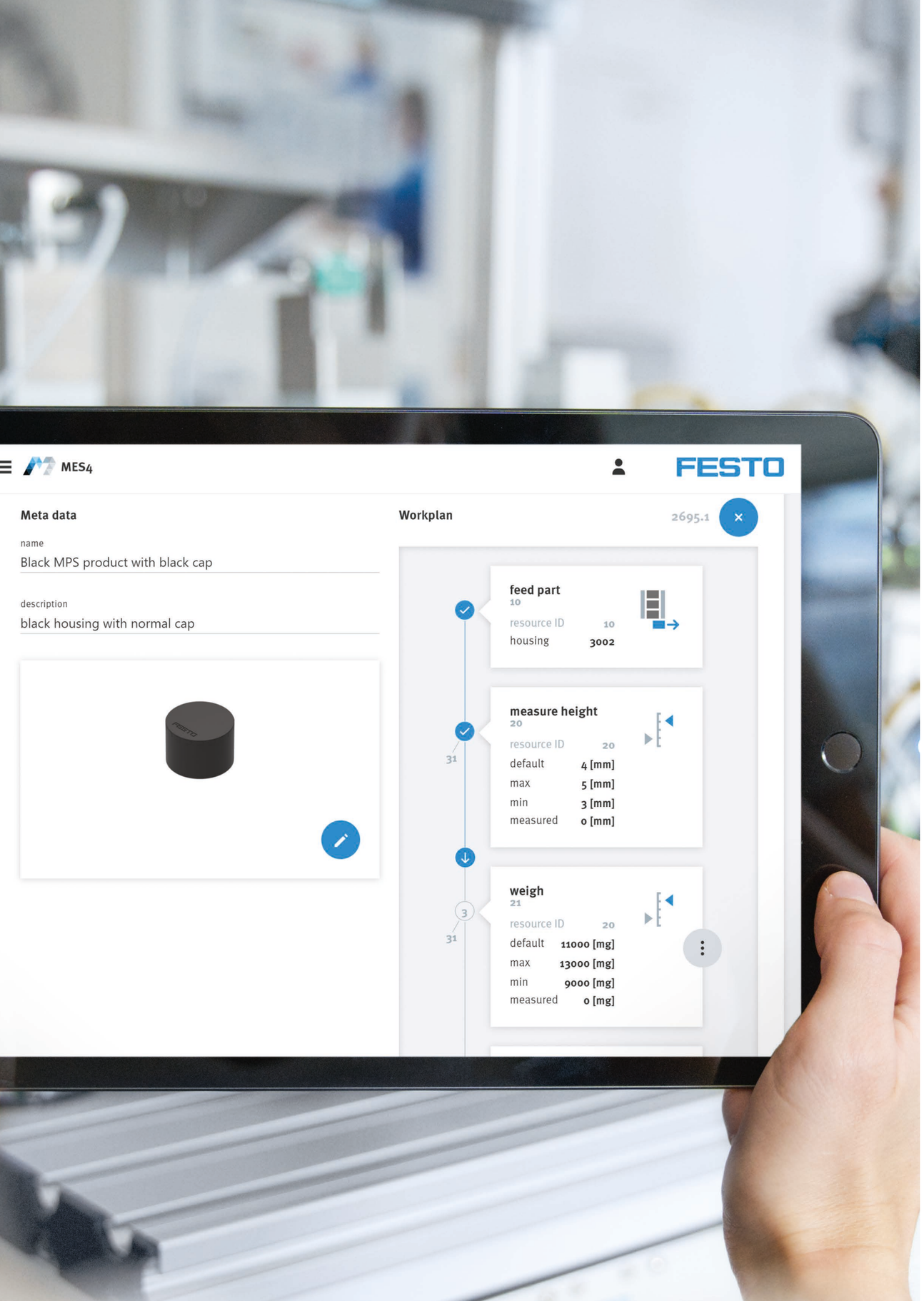
Your benefits at a glance
- One central access point for all factory automation software products
- Easy navigation between applications
- Facilitated saving and restoring of configurations and work statuses
- Location independent access to relevant information





"The biggest digital developments are happening in the invisible area – the software area. With FactoryViews, these changes are didactically prepared and thus made tangible!"

Dr. Stefan Kapp
Product Manager, Factory Automation Software



Learning content and technology areas

Manufacturing Execution System (MES)

Industrial relevance

The Manufacturing Execution System (MES) is responsible for controlling production in real-time and thus assumes a central software function in manufacturing. The MES is used to manage production resources, plan and monitor production processes and record operating data. In addition, it communicates continuously with adjacent systems and determines key figures such as availability or effectiveness, whereby production processes can be optimized further and further.

Use in the MPS

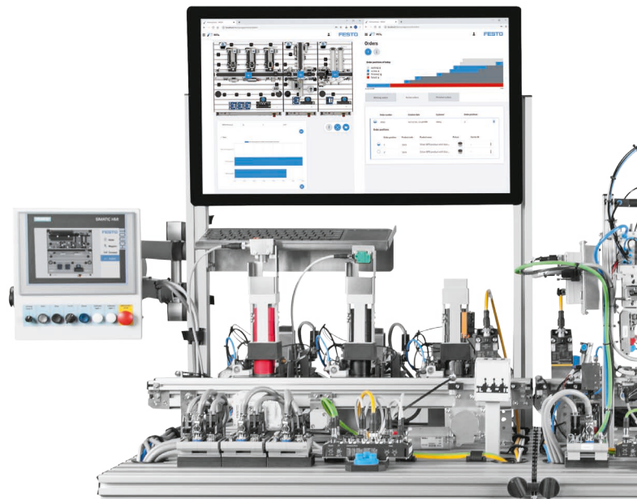
The MES4 is specially tailored to meet all education requirements for our learning factories. We rely on open interfaces and databases and cross-manufacturer communication standards such as OPC UA. The MES4 V3 at the MPS maps all the essential features of an MES but remains simple and intuitive to operate – both on the integrated touch screen and in the browser of various end devices. Again and again MES4 can also be coupled with the CIROS simulation software. This creates new learning scenarios, inside and outside the laboratory.

Learning materials

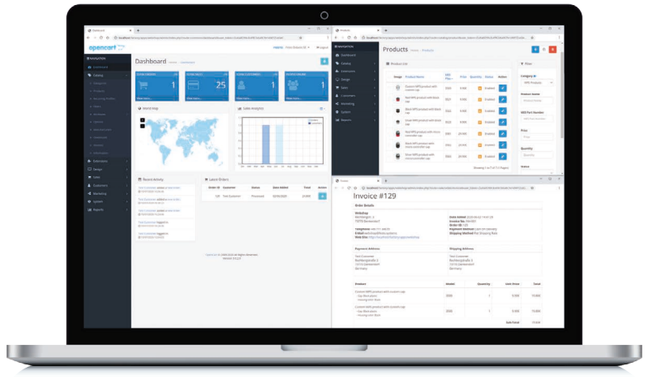
With industry-minded workbooks and digital courses, learners acquire the basics in production planning and control. Order, product and process data can be interpreted and implemented for order management, and work plans. Through data analysis exercises, learners optimize position, transport and cycle times and derive initial maintenance strategies.

Competencies gained

After completing the training on the MPS, learners gain a solid understanding of the different functions of the MES, and are able to interpret orders, process and product data. They know the system and communication interfaces and can independently analyze data from the database. By creating systems and products, transport and cycle times can also be interpreted and optimized. In the context of predictive maintenance, learners understand the advantages of the MES, the different roles, and can derive maintenance measures.



Web shop



Industrial relevance

The web shop represents the central platform for acquiring customers, handling orders, and, as well as automatic order processing and traceability.

Therefore, the web shop is closely integrated into the IT landscape of a company, taking tasks to the ERP area, which includes the management of product prices and other marketing measures.

Use in the MPS

The web shop extends learning into areas of ecommerce, driven by the ability to map processes for ordering and managing online goods. This makes it easy to integrate e-commerce topics into learning scenarios.

On the customer side, our web shop offers a simple, intuitive and realistic mapping of the business process – from registration to ordering to follow-up. On the administration side, typical tasks can be carried out such as managing the products offered in the web shop with multimedia descriptions or configuring prices or discounts.

Learning material

Through hands-on learning, workbooks, and digital online courses, learners have access to comprehensive learning methods that cover the entire basis for web shop comprehension. Learners also gain an understanding for the power of web shop through the perspective of the employer as well as the customer.

Competencies gained

Learners will gain an understanding for the basic terms in the context of ecommerce. They can create and configure new products in the web shop. Learners can also classify and implement the entire handling process from the receipt of the order, i.e. the product order, to the order processing. In doing so, they get to know the interfaces of the web shop to the IT environment.

Learning content and technology areas

Human-Machine Interface (HMI)



Industrial relevance
Modern production plants continuously supply data. An industrial touch panel visualizes it for the plant operator in real-time. In contrast to static control elements, a touch panel offers a context-sensitive operating option and thus supports flexible interaction with the machine. Industrial standards ensure reliability in the rough and tumble of everyday industrial life.

Use in the MPS
In the MPS, the subject of human-machine interaction is taught from the very basics. In addition to physical buttons, signal lights and an analogue potentiometer, the focus is on the industrial touch panel. The learners begin to use simple visualizations to build complex interfaces consider eliminate that can be used to interact with the machine. Among other things, the touch panel is used to parameterize and monitor the IO-Link-based smart sensors and to visualize their sensor values. The conveyor belt with its current sensor values is also displayed.

Learning materials
With the help of workbooks and digital courses, learners acquire basic knowledge about the structure and function of an HMI. In numerous practical tasks, they learn how to integrate and parameterize various visual operating elements independently of each other in a user interface in order to connect sensors and actuators of the MPS Distribution Pro.

Competencies gained
After completing the learning units, learners are familiar with the structure and function of the TIA Portal and WinCC. They can explain the structure and function of an HMI panel and corresponding applications. Taking into account the ergonomic style guide, learners create basic objects, elements and functions and design a user interface in the context of the MPS system. They can commission the HMI and parameterize actuators and sensors independently and are able to interpret malfunctions and derive solution strategies. Furthermore, they can export significant key figures, such as cycle times, and prepare them for further analysis.



“MPS 403-1 is a real milestone in the history of MPS. The learning system teaches both concepts of highly customized production and new technologies in the production environment, such as artificial intelligence and machine learning. At the same time, the entire fundamentals in the field of mechatronics and automation technology can be taught on one a single learning system:
A real all-rounder.”

Alexander Abdo
Product Manager since 2016

Smart sensors with IO-Link



Industrial relevance
Sensors are used to detect environmental conditions. Modern IO-Link-based smart sensors are increasingly replacing classic analogue and digital sensors. In addition to the actual sensor values, the intelligent sensors provide additional data, such as information on the degree of contamination of the sensor, and thus on the reliability of the sensor value in the form of digital data. This increases the quality of the recorded data, and sensor failures can be reduced or even completely avoided.

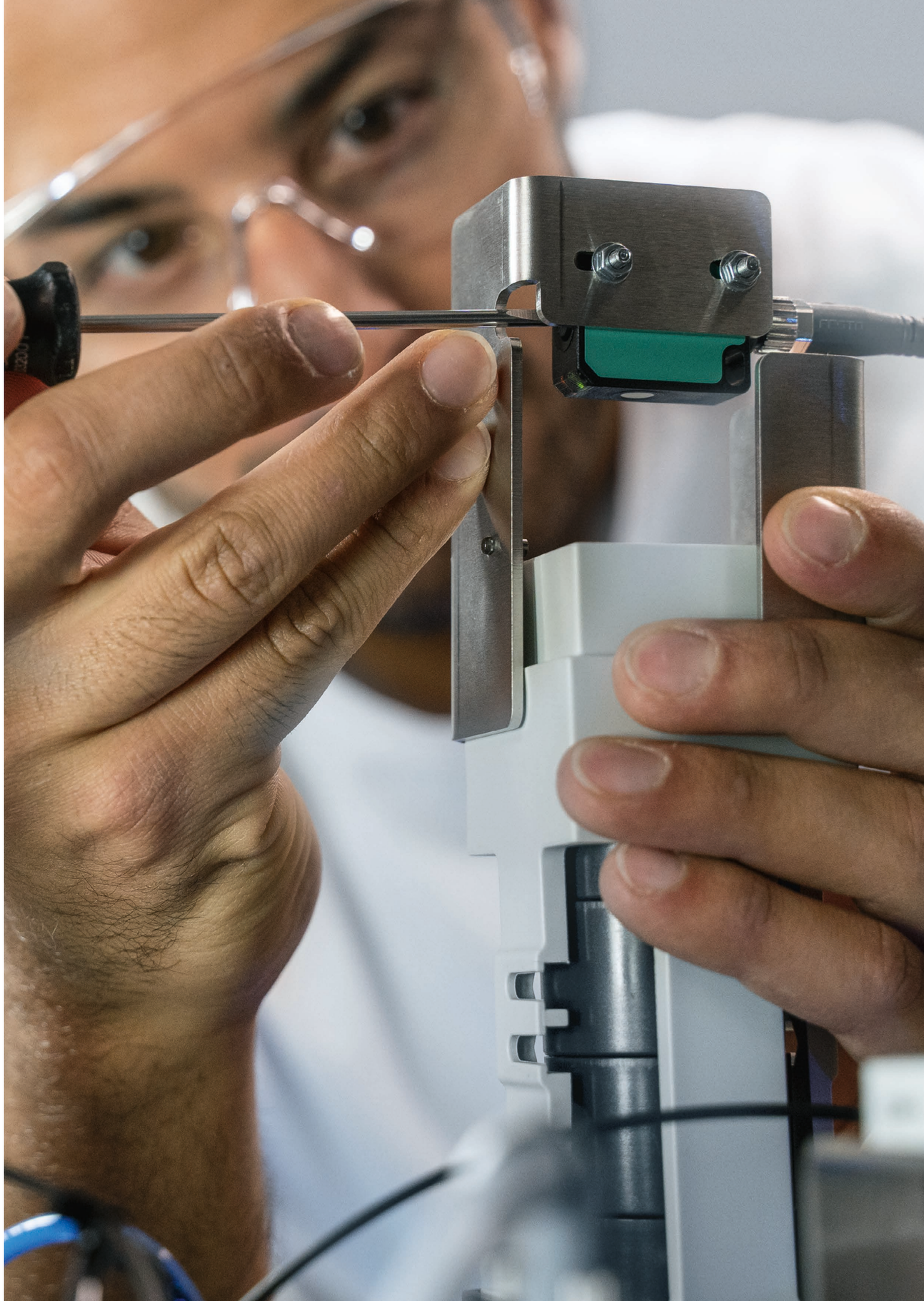
Use in the MPS
The MPS 400 Distribution Pro system module contains three intelligent sensors. The three stacking magazines are each equipped with one of these smart sensors. An ultrasonic sensor, a capacitive sensor, and a laser sensor monitor the fill level of each of the stacking magazines. The sensors are connected to the PLC via a separate IO-Link controller. This in turn transmits the fill level information to the central MES system.

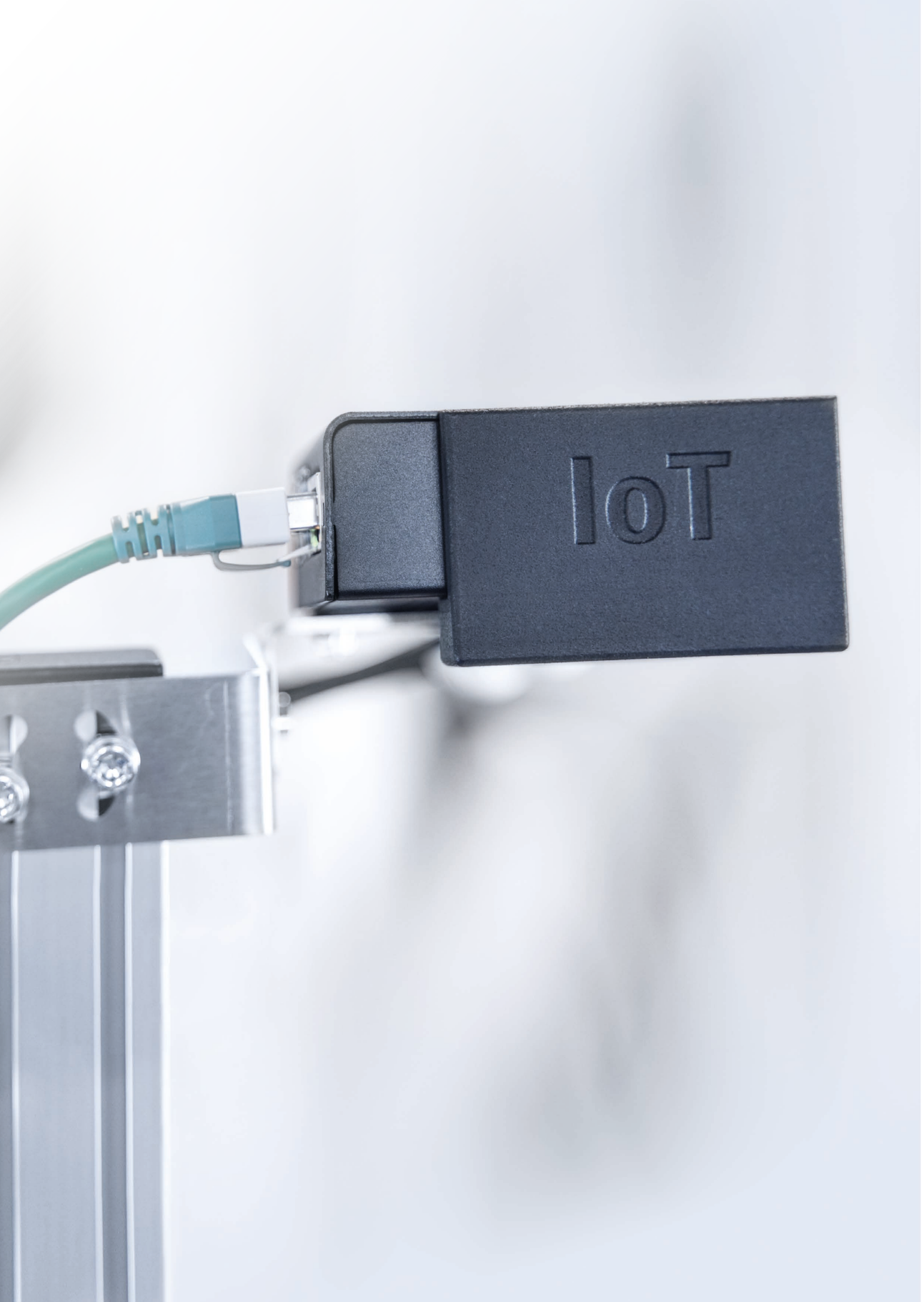
The fill level detected in this way is visualized both in the MES and on the system's touch panel.

Learning materials
With the help of workbooks and digital courses, the learners acquire the basics in the field of smart sensors. Under the umbrella term industrial IOT in production, they learn in numerous practical tasks about different sensor types as well as integration into the overall system and parameterization at the MPS Distribution Pro station.

Competencies gained
After completing the training, the learners know the different sensor types and their advantages and disadvantages compared to classic sensors. They are able to parameterize intelligent IO-Link sensors, load configurations and integrate them into a PLC project. They understand the basic features of the IO-Link protocol, can integrate IO-Link-based components into the plant network, and display them visually via the HMI.

In the context of maintenance, the learners know about the advantages of intelligent sensors and can derive maintenance measures.





IIoT retrofitting

Industry relevance
Unpredictable market conditions exert constant pressure on manufacturing companies to adapt. At the same time, existing production processes and facilities should not be interfered with to endanger the system's stability and reliability.

Retrofitting existing production plants with IIoT devices (Industrial Internet of things) offers an sophisticated way to collect additional data without directly intervening in the system. In this process, small sensors equipped with their own intelligence are attached to existing plants in the form of IIoT devices without changing existing PLC programs. The data obtained is often evaluated directly on the device and made available to the business process.

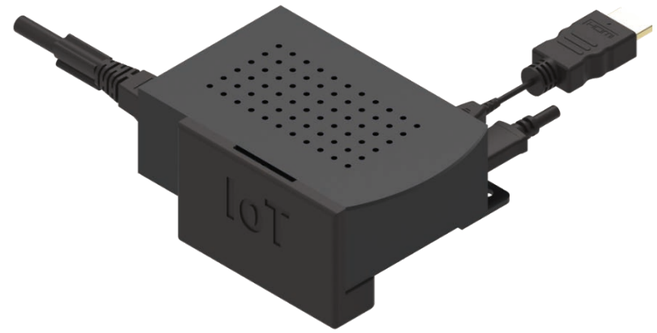
This helps decision-makers optimize processes and make them more flexible, improve the quality of decisions and open up new business models.

Use in the MPS
The workpieces produced in the learning system are sorted into two chutes at the end of the production process. A small computer independent of the production system with an integrated webcam monitors the filling level of the chutes and triggers a warning message depending on the capacity of the chutes and the number of workpieces.

The webcam continuously takes photos that are evaluated by a machine learning algorithm directly on the small computer. After a certain learning phase, the algorithm recognizes individual workpieces and thus the number of workpieces per chute.

Learning materials
Through the support of various digital, and print media, the topics of efficiency, performance, and service life are communicated in the context of retrofitting. The focus is on the digital transformation in production. Individuals will learn about the importance and possibilities of IoT and apply them in practical tasks. New business models and cybersecurity play an essential role.

Competencies gained
Learners are taught the challenges that companies are confronted with in the course of the digital transformation. They can classify the possibilities of IoT and transfer them to different scenarios, such as condition and remote monitoring. They know the approach of retrofitting and can carry out a retrofit on a system. The learners are able to derive measures to increase efficiency and the effects on new business models and maintenance strategies. Furthermore, they can classify and critically evaluate the effects in the context of cybersecurity.



Artificial Intelligence and Machine Learning

Industrial relevance
Artificial intelligence (AI) is used in numerous industrial areas, for example, for (optical) quality inspection, proactive maintenance to minimize downtime or, save resources through data-driven process optimization.

Machine learning or deep learning based on neural networks has proven particularly promising for the automated analysis of data. Increasing computing power – both on the production line itself and in the cloud – makes it possible to analyze and classify huge amounts of data and derive profitable conclusions.

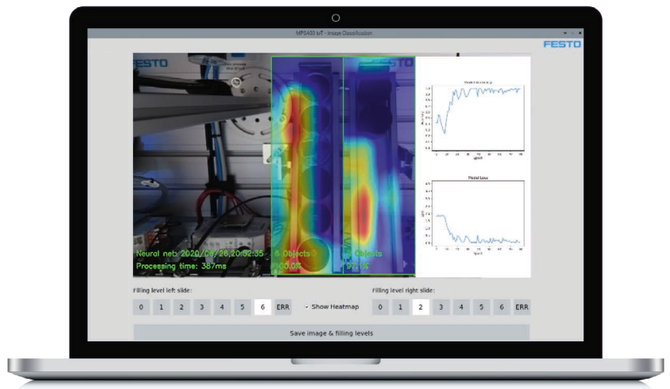
With AI in production, a paradigm shift has also begun: such systems are no longer programmed but trained. They can continue to optimize themselves during operation, making them a robust approach in a wide range of applications.

Use in the MPS
The workpieces produced in the learning system are sorted into two chutes in the Sorting Inline station at the end of the production process. A small computer independent of the production system with an integrated webcam monitors the filling level of the chutes and triggers a warning message depending on the capacity of the chutes and the number of workpieces.

The camera continuously takes photos that are analyzed directly on the small computer via machine learning with regard to the filling level. The neural network used is able to further optimize itself with each photo and thus determine the correct number of workpieces with high accuracy.

Learning materials
With the help of workbooks and eLearning digital courseware, learners acquire basic knowledge in the areas of artificial intelligence, machine learning and neural networks under the umbrella term industrial IIoT in production. In numerous practical tasks, they learn how to successfully apply the concept of “supervised” learning to the MPS Sorting (Inline).

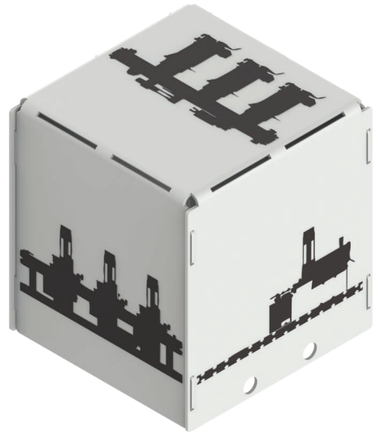
Competencies gained
After completing the training, learners understand the principles of machine learning and deep learning and are able to interpret simple neural networks, and design, train, and use them independently. Furthermore, they are able to explain and compare different algorithmic approaches, such as supervised and unsupervised learning.







Augmented reality



Industrial relevance
Augmented reality digitally expands the perception of reality. Used sensibly, maintenance staff, technicians, or planners in the industry receive exactly the correct information or interaction options at the right time and in the right place via networked mobile devices. This enables them to carry out their work faster, more efficiently, or more safely than with conventional sources of information or operating options.

Use in the MPS
The free AR app for iOS and Android digitally enriches the MPS 400 learning factories with content and interaction possibilities. The three AR marker cubes on the MPS reliably recognize the stations and additional content is precisely displayed. Extended tracking then enables free movement around the stations. Clear menus lead to the appropriate content, such as technical data, videos, animations, live data or commissioning steps. Thus, AR ensures a smooth teaching process and a more efficient learning process, as it supports independent learning.

Learning materials
With the help of workbooks and digital courses, learners develop the application potential of AR in the context of maintenance. They learn to analyze and interpret data using mobile devices.

In numerous practical tasks, they learn, among other things, how to create and design AR scenes themselves. They can classify the most diverse levels of maintenance and derive initial strategies for optimization.

Competencies gained
After completing the training, learners will be able to use AR technology in a targeted manner in the context of maintenance. They can access relevant information in real-time and thus carry out systematic maintenance. Learners are able to create their own AR scenes and adapt them to changing circumstances.

They are familiar with the handling of different end devices and can use the various software systems safely.

Industrial networking with PROFINET





Industrial relevance
Modern production systems consist of many networked individual components that provide their environment with constantly growing amounts of information. These components are increasingly linked to each other via network-based connections, as purely IO-based communication cannot cope with these data volumes. Industrial Ethernet has therefore established itself in the production environment as a powerful and efficient communication path. Profinet is one of the most important communication standards. Thus, a sound understanding of the structure and safe handling of protocols such as Profinet is a fundamental requirement of today's industry.

Use in the MPS
In the MPS 400 learning system, various components are addressed via network-based protocols. In addition to RFID controllers, an IO-Link controller is also connected to the control level via Profinet. An IO-Link-based bus coupler links a series of remote, digital IOs with a PLC. A protocol-specific BUS head translates the IO-Link protocol into a communication format that is understandable for the control level - in the case of the Siemens controllers used here, Profinet. The Industry 4.0 interface OPC UA can also be used for network-based and platform-independent communication with the controllers, e.g., to query and visualize sensor values or process states or to establish connections to cloud applications.

Learning materials
With the help of workbooks and digital courses, learners acquire essential basics in the field of industrial networking.

In various hands-on tasks, they learn network-based protocols and communication to the components, including different types of smart sensors.

Competencies gained
After completing the training, learners will understand the advantages of standardized communication through PROFINET. They can classify the associated opportunities and their significance for communication between machines and industrial systems. They can map data exchange between different devices with the help of protocols such as MQTT. As a result, they are familiar with the most diverse types of data in vertical and horizontal communication. Furthermore, they are able to network different software and hardware components.





Learning content and technology areas

PLC programming and industrial communication with OPC UA



Industrial relevance
The constantly growing number of software modules is permanently changing the classic automation pyramid and thus the underlying communication and architectures. Classically sequential processes give way to service-oriented program structures and bring a new dimension of complexity in PLC programming. At the same time, protocols such as OPC UA facilitate open data exchange between components from different manufacturers and thus vertical and horizontal communication within the automation pyramid. These changes pose new challenges for mechatronics and automation engineers.

Use in the MPS
The PLC programs of the MPS 400 learning system are in line with the new requirements of service-oriented architectures. The focus is on communication with the MES and higher-level software modules. In addition, individual process data are made available to the environment via OPC UA. For example, the travel times of cylinders can be monitored via OPC UA. This data can be used for preventive maintenance, for example. In addition, the value of the ultrasonic sensor that monitors the fill level of a stacking magazine can also be read out via OPC UA.

Learning materials
Workbooks and digital courses support students in getting started and deepening their knowledge of PLC programming in the context of Industry 4.0. In the process, they learn about different types of blocks and operating modes and find out how these are implemented in a PLC program.

Competencies gained
After completing the training, learners can independently carry out an extended device configuration and commission a PLC. They know the common operating modes and can create a modular program structure using the software. Learners independently develop and parameterize various program modules. They know the different interfaces and are able to integrate relevant technologies such as RFID, MES (OPC-UA) into a PLC program.

Learners are able to carry out systematic troubleshooting for different error scenarios and thus optimize a PLC program structurally.

“On a recent visit to a technical school in Sao Paulo, Brazil, I actually found one of the original A Release (pre-1997) MPS systems still in operation in the automation lab – a clear indicator of the quality of our learning solutions.”

Theodoros Ktistakis
Product Manager from 1989 to 1993
Global Education Projects



RFID – Digital product memory for flexible manufacturing

Industrial relevance
The increasing complexity in production has been triggered in part by the growing demand for high-volume customized products. As a result, the industry moves further away from traditional mass production towards flexible mass production. This development towards batch size 1 production can only succeed with the help of unique identification of products and orders. Radio Frequency Identification (RFID) is a basic technology that enables precisely this and is already widely used.

RFID is a technology for transmitter-receiver systems that is used to identify and locate objects automatically and without contact. This allows products to be clearly tracked throughout the entire production process and beyond, significantly reducing the complexity of customized production with a high diversity of variants. For this reason, RFID technology is an essential component of every modern manufacturing system.

Use in the MPS
Each of the three MPS stations is equipped with an RFID read/write head and an RFID controller. This enables the system to communicate with the digital product memory on the RFID tag of the workpieces.

To learn RFID technology from scratch, a set of controller and read/write head can be removed from the system. This combination can be addressed via the web browser of a laptop on a work table. RFID tags can be read and written in a simple way, without integrating the RFID controllers into a PLC.

Learners then integrate the RFID devices into the PLC, ensure communication with the MES and integrate RFID into the overall context of the plant. A redesign of the software architecture and the communication paths in the plant enables service-oriented structures, away from sequential processes.

Learning materials
With the help of workbooks and digital courses, learners acquire basic knowledge of various identification systems, number systems, and RFID technology.

In numerous practical tasks, they learn what is behind the term “product memory” in the context of the entire MPS 400 and how it is programmed and used, considering various influencing factors.

Competencies gained
The practical training at the MPS 400 prepares learners for the industrial application of RFID technology, empowering them to design and integrate RFID for existing production facilities. A major focus is also on the development of troubleshooting strategies. This enables learners to anticipate and avoid known challenges and sources of errors and develop adequate solutions. Learners know about the advantages and limitations of this technology, including in the context of data security.







04 | MPS 400
Additional packages

Mobile robotics

Industrial relevance
Small batch sizes increase the competitiveness of production lines. At least that is the theory. Because even with individually trackable workpieces, production lines remain rigid and allow the competitive advantages of flexible production to fizzle out.

Only flexible material flows with adaptable work schedules, and flexible capacity control can raise this potential. To enable manufacturing in production islands, material flows must be able to be diverted flexibly without production sequences and their throughput times becoming unreliable. To meet this challenge, a deep understanding of mobile robotics is a prerequisite: the strengths and weaknesses of AGVs versus AMR. For example: while established automated guided vehicles (AGVs) score high on robustness and throughput, autonomous mobile robotics (AMR) systems master dynamic route planning and are thus more flexible to use. Whether working side-by-side or planning, for successful production according to I4.0, it is important to internalize the modes of operation and limitations of mobile robot systems.

Use in the MPS
With the Robotino ecosystem, Festo provides the right building blocks to flexibly expand the MPS learning fields with the topic of mobile robotics. With our gripper kit, the transport of workpieces between the stations of the MPS 400 series can be realized on three levels:

Level 1 – With the prepared sensor kit, Robotino inserts itself between two stations and transports workpieces without the need for further communication.

Level 2 – Through communication via OPC UA, Robotino can supply several stations with workpieces, starting from the sender station.

Level 3 – Thanks to its complete integration into MES4 V3, Robotino is ready for flexible transport scenarios and can transport workpieces back and forth between any number of stations.

For each level, we provide a suggested solution. However, for the majority of behavioral routines and procedures, there are also alternative solutions that can be exchanged, changed or reprogrammed in class accordingly.



Learning materials
With the help of workbooks and digital courses, learners acquire a broad knowledge of the topic of mobile robotics. Practical tasks take a holistic look at the topic, from commissioning to the various sensors and actuators of the robots. The focus is also on programming, which gives the learners an insight into the versatility of the system.

Competences for action
After completing the training, learners will be able to put Robotino into operation independently. They know the different sensors that are necessary for autonomous control. They can program different scenarios, such as path tracking. With the help of different technologies, learners can classify and implement topics such as image processing and 3D measurement.

Machine safety

Industrial relevance
To ensure safe cooperation between man and machine, important standard guidelines on machine safety have become established in industry. The Machinery Directive contains a series of specifications, compliance with which can ensure maximum safety in the use of a machine. It is therefore considered a fundamental set of rules in the design process.

A prerequisite for the successful implementation of safety guidelines is that not only developers and designers, but also machine operators are familiar with the corresponding contents. This need for qualification should therefore be covered in training.

Use in the MPS
With the TP 1321, the common safety devices of modern machines can be mapped and learned using practical examples. The modular system consists of a modular door structure, safety relays, and safety switches and can be used in stand-alone operation, in conjunction with the FluidSIM simulation software or attached to an MPS station. Elementary concepts in machine safety are taught in a holistic learning environment. All that is required is to integrate the TP1321 with the appropriate attachment kit into the MPS 400. Converted in just a few steps, the system can be used to implement ever new safety features in practice.

For example, a risk analysis can be carried out, its results interpreted, and the necessary steps initiated directly if action is required. Various doors and their security options can be used as standard. Optionally, the package can also be expanded to include a light curtain.

Learning materials
With the help of workbooks and digital resources, the learners acquire basic knowledge on machine safety. Standard safety switchgear, its design, function, and areas of application are taught.

The practical tasks are carried out in the context of various scenarios directly at the station expose learners to this subject area.

Competences for action
After completing the training, learners know the different safety switchgear and their structures. They know the basics of the different types of operation, such as the two-hand circuit. Learners can set up different types of circuits in a real and simulated learning environment. They can carry out troubleshooting and independently derive improvement measures with regards to machine safety.





Energy monitoring



Industrial relevance
The industrial sector is responsible for a significant proportion of the global energy demand and thus for costs and environmental pollution. To be able to document consumption and achieve visibility, comparability and evaluability, monitoring systems are temporarily or permanently installed in modern production plants. Only with this basis can costs be allocated, efficiencies compared, potential for improvement measured, and implementation documented.

Consumption data are valuable indicators of the health of machines, so that in the event of deviations, measures can be taken at an early stage to maintain productivity.

Use in the MPS
The supplementary package Energy Monitoring contains coordinated components for teaching energy efficiency at the MPS 400. The energy measuring box with industrial sensors for measuring electrical power consumption and compressed air is connected to plug connectors. Independent measuring channels are prepared for three stations. The Energy App for FactoryViews takes care of communication with the measuring box, data logging, and the preparation of the data on clear dashboards. The appropriate training tasks can be practically implemented with the included pneumatic components, the vacuum saving valve, and the leakage simulator.

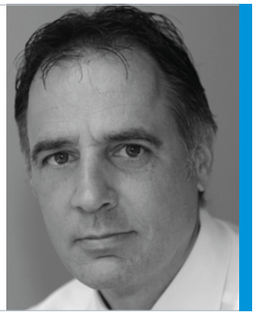
Learning materials
Learners acquire everything important about energy efficiency in production with the help of workbooks, digital courses, and tutorials. Practical tasks impart knowledge on the relevant areas such as data acquisition and measurement. The subsequent analysis and evaluation of the results and the concrete derivation of improvement measures using various learning scenarios as examples round off the topic holistically.

Competences for action
After completing the training, learners will understand the basics of energy efficiency and the related ecological aspect. They can derive different measures to increase energy efficiency in production.

They will know common forms of representation, such as the Sankey diagram. Using various key figures, learners can carry out a profitability analysis of the overall system.

“With the introduction of the MPS C release, we established MPS as a mainstay of Festo Didactic MPS and mechatronics became an international standard. With more than 1,000 new systems installed every year, MPS became a key guarantee of success for training in mechatronics and indispensable in training centers worldwide.”

Eckhard von Terzi
Product Manager from 1998 to 2005
Currently Head of Global Sales and Service Center



IT security

Industrial relevance
Digital communication networks are the backbone of modern production facilities. The networking of production sites, systems, and components will continuously accelerate. Data flow within the company and its sites and to partners in the value chain. Data security, as well as data availability, are becoming increasingly important, especially since the amount of data will increase exponentially in the future.

Worldwide, several million cyber attacks are launched every day. In the worst case, these cyber attacks can threaten the existence of small and medium-sized enterprises in particular. Therefore, not only the basics of networking, but also ensuring data security are important content in apprenticeships. In their future working lives, trainees and students will deal intensively with networks and their security.

Use in the MPS
The additional IT security package contains coordinated components for training IT security on the MPS 400. The two EduTrainers with a Siemens S615 router, a Siemens XC208 switch and a software package are used as one system with the PLC controllers used in the MPS 400. The task blocks in the supplied courseware contain a number of subtasks that are graded in difficulty. As a rule, they start with simpler problems and then increase in difficulty. Depending on the training occupation and the level of knowledge and skills of the trainees, trainers and teachers can select the subtasks they consider suitable for their mechatronics, industrial electronics and IT specialist trainees.

Learning materials
With the help of workbooks and digital courseware, learners acquire basic knowledge on topics such as switching and monitoring. Numerous hands-on tasks impart knowledge in the areas of routing and firewall functions, and also, how attacks can be warded off and what contribution can be made in the company environment from the employee's point of view.

Competences for action
After completing the training, the learners will understand the common terms in the context of cybersecurity. They can analyze the security requirements of industrial communication systems and classify the different terms, such as switching and monitoring.

They will know the hazards and risks and can derive and apply safety measures, such as protection against sabotage or safeguarding manufacturing know-how.

