PLATAFORMA E-LEARNING

E-LEARNING SYSTEM WITH VIRTUAL REALITY FOR INDUSTRIAL AUTOMATION TRAINING

DL VFA4.0 – VIRTUAL FACTORY AUTOMATION

The DL VFA4.0 is an e-learning platform with built-in courses that has been developed to teach automation in practice, through distance learning. Main characteristics of this e-learning system:

- **Industrial grade:** the courses and virtual environments included in this platform are very trustworthy and easy-to-use
- **High quality:** it is an innovative and reliable solution with the following features:
  - the virtual reality makes students feel inside an industry
  - active learning approaches keep students engaged
  - gamification let students learn and have fun at the same time
- **Quick launch:** built-in courses grant easy-to-use and effective tool to train students on virtual factory automation.
- **Time-saving**: the automatic guidance and validation of the platform save teachers' time during the courses, so the same teacher can support more students.

The DL VFA4.0 is a platform designed to teach automation and, since the developers are also teachers, it has two main purposes:

- Improving the learning experience by creating realistic situations
- Reducing the teachers' effort by automating tasks and providing dashboards

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AVAILABLE COURSES AND DISCIPLINES

De Lorenzo's goal is to cover every practical discipline in technical and engineering courses with virtual reality environments, built-in e-learning courses and other resources.

The built-in courses can be offered as technical, graduation, post-graduation or qualification modules/disciplines. However, the teachers may adopt them as they are and/or make continuous improvements in the courses by adding contents and other resources, and/or create new courses in partnership with our e-learning team.

The machine automation courses include versions with Siemens Classic Step7, TIA Portal, and Codesys. Since the platform has drivers for Rockwell SoftLogix and Modbus/TCP, new versions for teaching with other PLCs can be quickly implemented.

The machine vision course includes one version with Cognex In Sight platform.

The SCADA system courses are built to teach how to develop such applications with Codesys Visualization, Elipse E3 and Siemens WinCC.

AVAILABLE BUILT IN COURSES

Develop automation systems for machines and small processes

Develop machine vision applications for industry.

Design, implement and improve dynamic control systems.

Develop complimentary features in SCADA systems, using scripts.

Development of SCADA systems for monitoring and operation.

Development of automation systems with multiple modules.

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LIST OF AVAILABLE COURSES AND EXPERIENCES

MACHINE AUTOMATION:

- AUTOMATING THE GATE OF THE FACTORY ACCOMODATIONS BUILDING
- MANUAL OPERATION OF THE GYPSUM DOSING AND MIXING LINE
- AUTOMATION OF THE GYPSUM DOSING AND MIXING LINE
- IMPROVE THE AUTOMATION SYSTEM OF THE GATE
- AUTOMATING THE LINE USING STATE MACHINES (SFC)
- AUTOMATING THE FACTORY ELEVATOR
- AUTOMATING THE INK COLORING PROCESS

DYNAMIC CONTROL SYSTEMS:

- STUDYING AND EXPERIMENTING THE SYSTEMS
- OPEN-LOOP CONTROL
- TRANSIENT AND STEADY STATE RESPONSE
- ON-OFF CONTROL
- PROPORTIONAL CONTROLLER
- SIEMENS PID BLOCK
- PI CONTROLLER
- PD CONTROLLER
- PID CONTROLLER
- ZIEGLER-NICHOLS METHOD (CLOSED-LOOP)
- ZIEGLER-NICHOLS METHOD (OPEN-LOOP)
- OTHER PARAMETRIZATION METHODS
- AUTO-TUNING

SCADA SYSTEMS DEVELOPMENT:

- A SCADA SYSTEM WITH CODESYS VISU
- A SCADA SYSTEM WITH ELIPSE E3
- IMPROVING THE SOLUTION WITH ELIPSE E3
- A SCADA SYSTEM WIN SIEMENS WINCC
- A SCADA SYSTEM FOR THE DOSING AND MIXING LINE

MACHINE VISION:

- REAL TIME MEASUREMENT INSPECTION
- COUNTING COMPONENTS
- READING TAGS

SCRIPTS IN SCADA SYSTEMS:

- MODAL SCREEN UI/UX
- SAFE OPERATION IN MULTI USER SCADA SYSTEM
- EXTRA FEATURES

AUTOMATION WITH MULTIPLE SUBSYSTEMS:

- SEMI-AUTOMATIC OPERATION OF THE WAREHOUSE SYSTEM
- SAFE OPERATION IN MULTI USER SCADA SYSTEM

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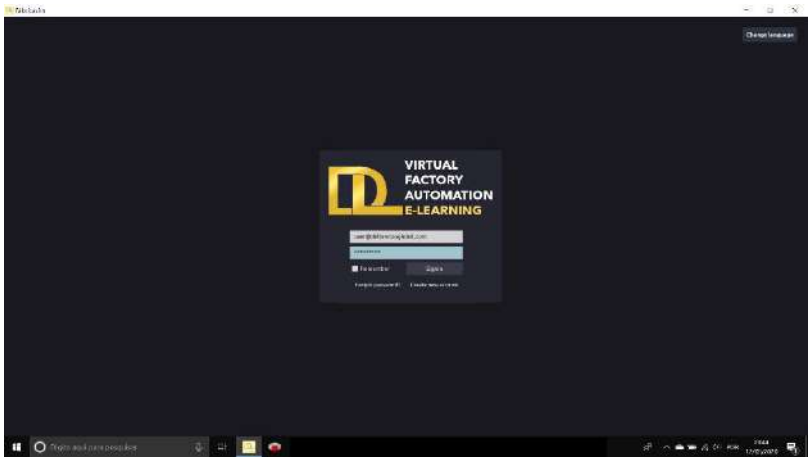
HOW DOES IT WORK ON THE PERSPECTIVE OF STUDENTS?



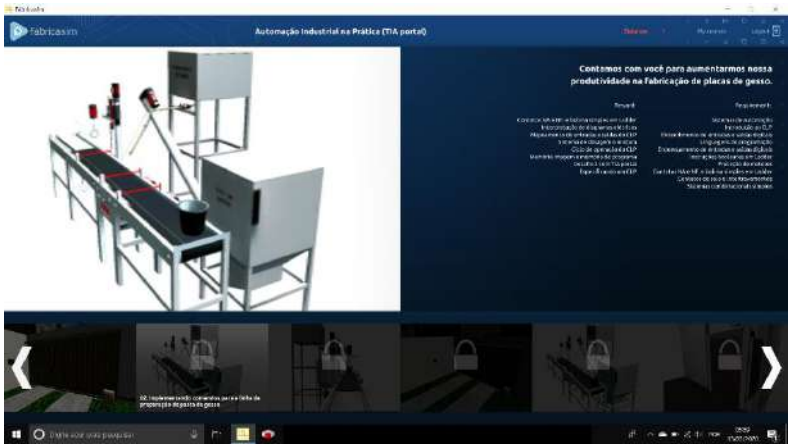
Downloading and logging into the platform

The student will download and log into the platform using the link provided by the educational school, with the authentication information (username and password).

Navigate the course's menu and access a course

When logged in the student sees the courses that the school has subscribed him to.

He/she may navigate throughout the courses and see the details such as contents and skills that will be developed.



Navigate the challenge's menu and access a challenge

By accessing the course, the student will see the challenge menu (bottom of the screen) as well as a description and the topics of the challenge (bottom-right).

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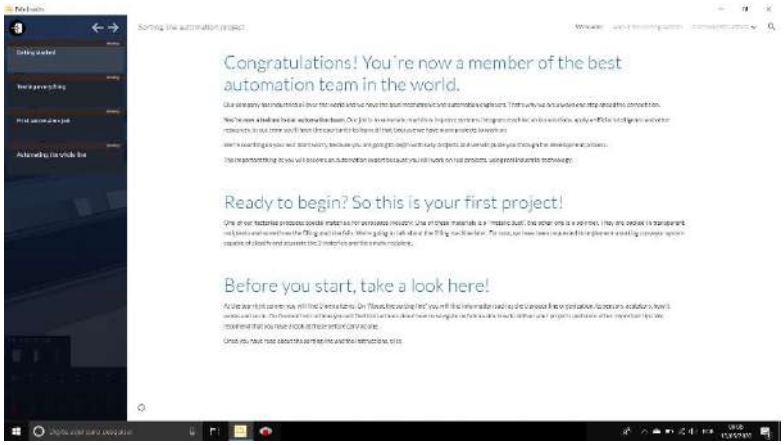

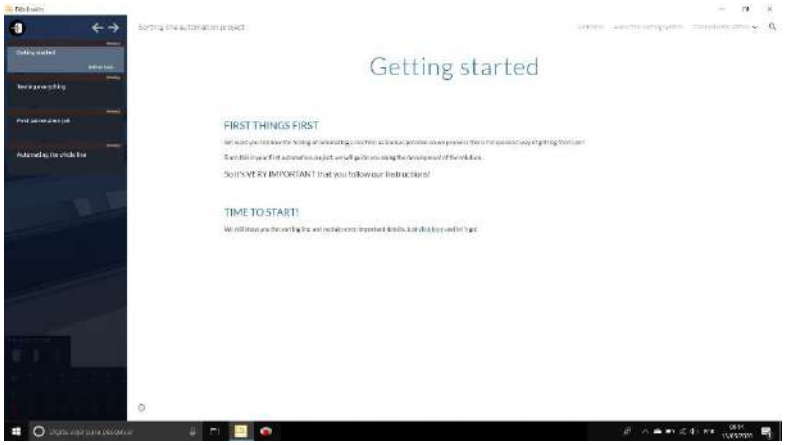

Access the challenge

By accessing a challenge, the student will see its presentation.

Since challenges are mostly projects in the automation courses, the student will be welcomed to the project team and will first learn about its goals, benefits expected to the factory, and the skills the student will develop by working on it

Challenges virtual reality environment

Every challenge takes place in a virtual reality environment. The case in the picture is a sorting line with conveyor belts.

This environment is controlled by a PLC or SoftPLC in case of automation courses, for example.

Accessing the tasks

Tasks are mostly project's steps. In this phase, the student is developing step-by-step the project.

This is important to keep the student focused on developing "small pieces", solving "small problems" and learning "small things". That keeps him/her engaged since he/she sees clear progress.

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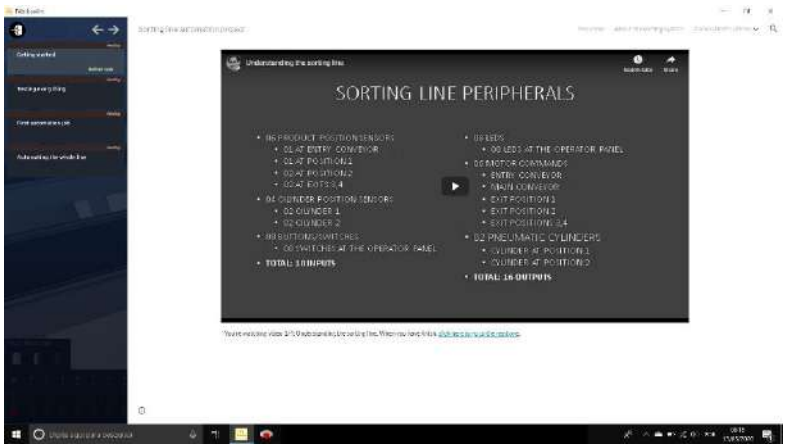
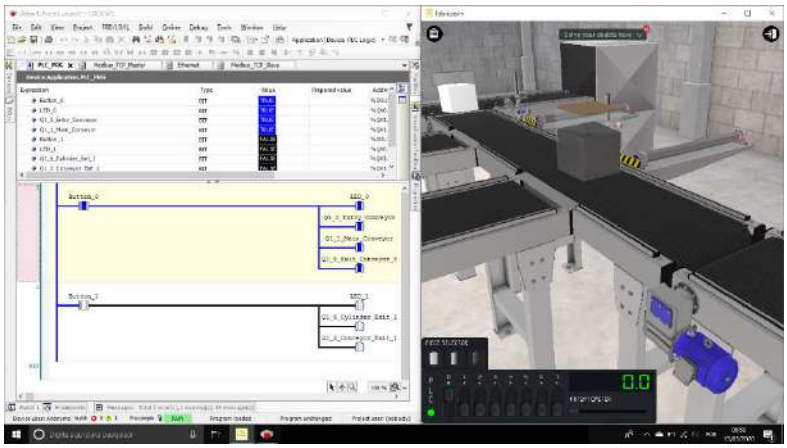


Accessing the contents

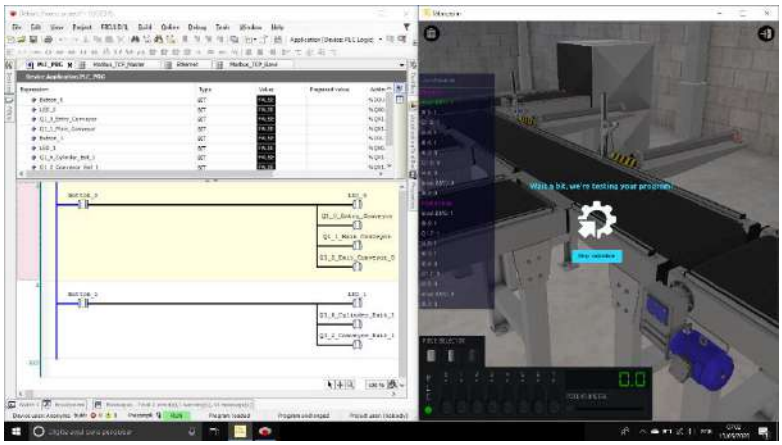
Every task has detailed instructions on what to do, how to do it and what must be learned to get the job done.



Developing and testing the application

The student will work with both DL VFA4.0 and the development software required to do the course. In this case, it is Codesys.

He/she will develop the application, and will test using real time simulation, in DL VFA4.0, as if they were in the factory.



Deliver a task

When the student comes to the conclusion that his/her solution meets the task's requirements, he/she may press the "deliver" button so DL VFA4.0 can test it in real time.

If the solution meets the requirements, the student is allowed to pass to the next task. If not, a feedback is provided.

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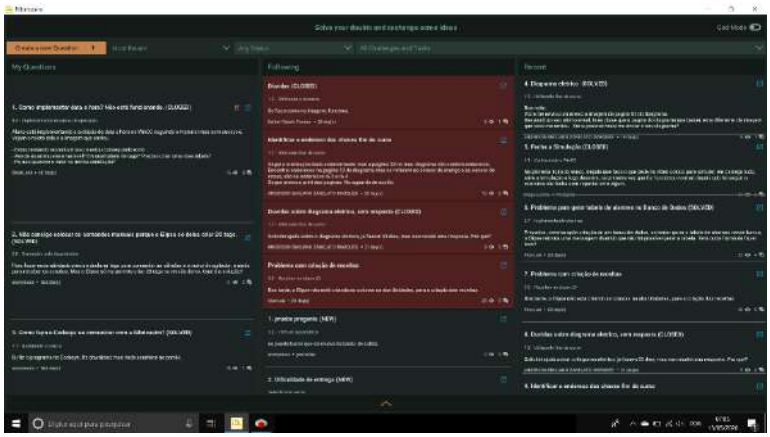

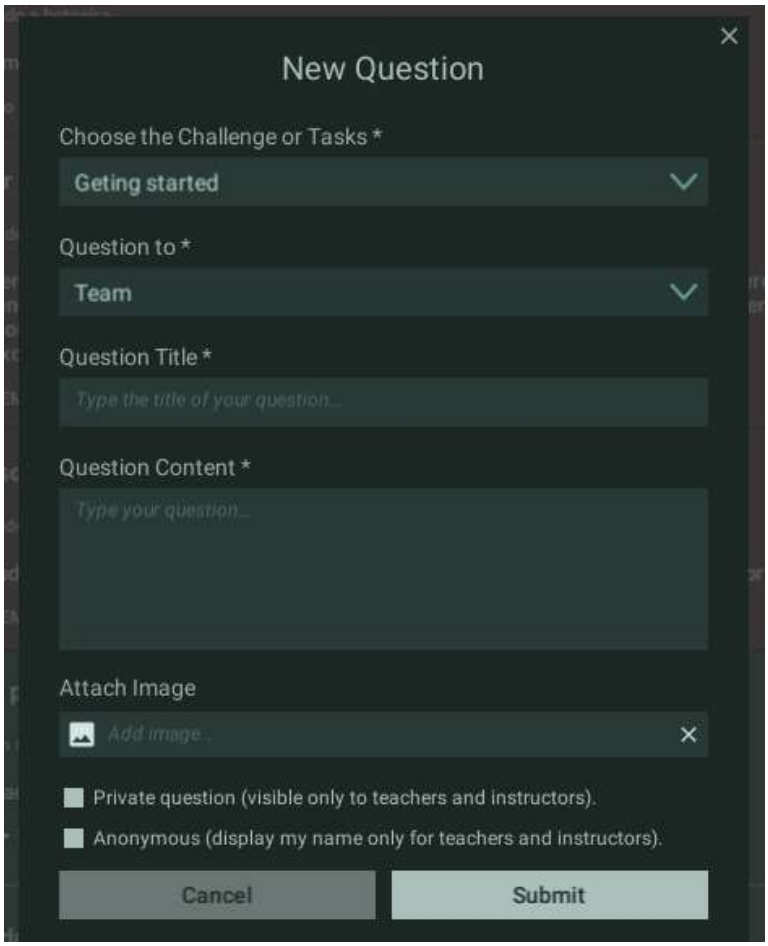

Ask a question to the teacher or the group.

If the student needs help, he/she may ask questions to the teacher, or to everyone in the course.

Besides, the students can easily see previous questions made about the tame task he/she is working on.

Anonymous question

It is important because many students are shy or uncomfortable to make questions in public.

The student may choose to have his/her name seen only by the teachers and instruction team.

So his/her question helps other students since it is going to be public, but in anonymous way.

Direct Questions

The student may make a question directly to the teacher and request him/her to answer.

The instructors may see it and anyone in the team may suggest an answer.

Therefore, if one of the monitors or assistant instructors in the course answer the question, the answer goes to the teacher as a suggestion, and the teacher may see it, request changes or only accept.

That means that the student will receive an answer from the teacher, but the teacher does not need to answer all of them. He may use the support of his assistance team.

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INFRASTRUCTURE OPTIONS

1. DE LORENZO'S SERVER AS A SERVICE

The DL VFA4.0 authentication and courses server may be delivered as a service, at De Lorenzo Server. That means that the school does not need to have any local infrastructure. That is a good option when the internet network is good at the school.

2. USB DONGLE

In case the student or the school does not have suitable internet connections, De Lorenzo can provide licensing through USB DONGLES. In this case, if the student works from time to time in the school and home, he/she needs to keep the USB DONGLE and a USB FLASH MEMORY with him. The USB DONGLE is required to use the system and the USB FLASH MEMORY is required to save the student's progress and course information so that when the student has an internet access, he/she may upload the information.

WHY IS DL VFA4.0 SO IMPORTANT FOR TEACHING AUTOMATION?

Many engineers and technicians are graduated without ever having developed an automation system, tuned a PID control, controlled a robot, integrated a machine vision system, or even opened any industrial electric panel.

If developing these skills and providing these experiences is already a challenge in presential courses where we can use equipment simulators, in distance learning it is an issue even harder to solve.

With DL VFA4.0 courses, it is possible to overcome this situation because they take place in industrial virtual environments. They include machines, processes, sensors, actuators, transducers, electric panels, wiring and many other components of an automation system.

All that is necessary to bring the student into the factory floor reality.

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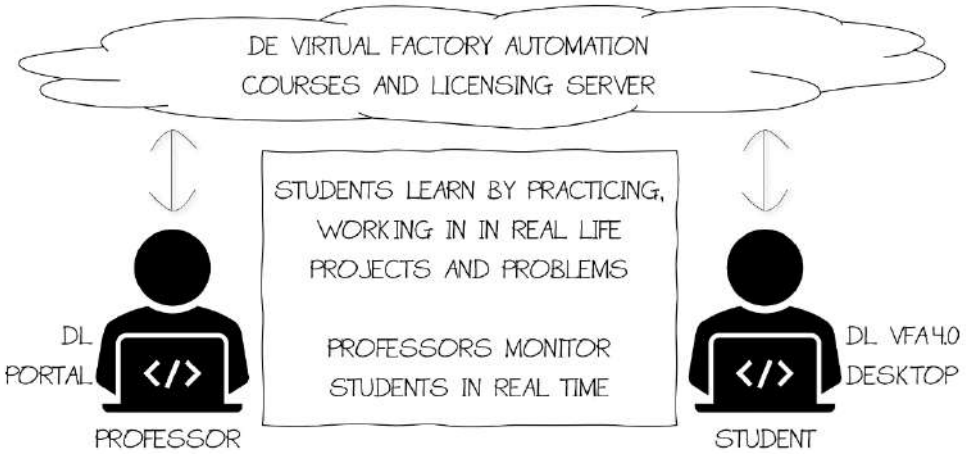
HOW TEACHER AND STUDENT INTERACT WITH IT?

The student downloads a desktop application to learn and communicate with the virtual reality and learning environments.

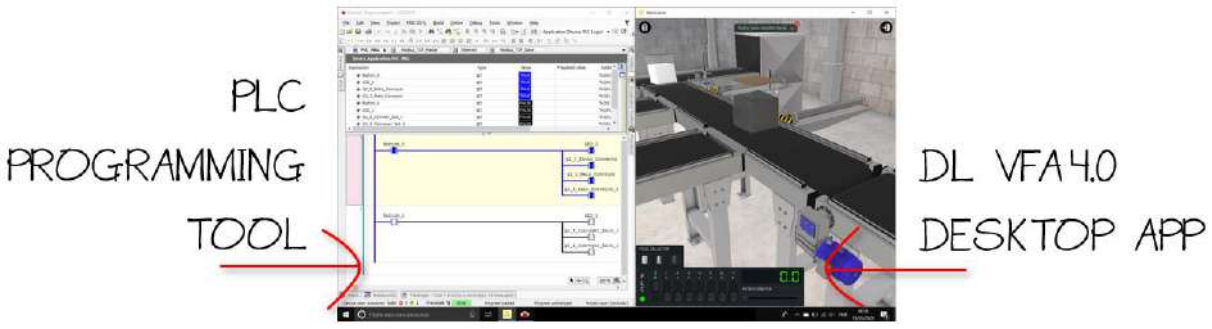
The teacher downloads the same application to work on activities and to communicate with the students. Moreover, the teacher has access to a cloud portal with dashboards and analytics so he/she is able to follow the group's progress in real time and identify students who need help.



WHAT SOFTWARES ARE EVOLVED IN THE PROCESS

The purpose of DL VFA4.0 is teaching automation and this always requires the use of some programming or design tools. With this platform, the student always works with DL VFA4.0 and the other tool opened in his/her PC.

The image below is taken from a course on automation and PLC programming, so at the left we can see Codesys Development Software and at the right, DL VFA4.0 desktop app.



Besides DL VFA4.0 and the programming tool, there is always another software is normally open in background that is the SoftPLC. In case of Codesys, it is Codesys Control Win. If the student were using TIA Portal, the SoftPLC would be PLCSIM and if it were Rockwell the SoftPLC would be SoftLogix.

If the course is on Machine Vision, for example, the programming tool may be Cognex In-Sight and if it were Artificial Intelligence, than it would be a Python IDE.

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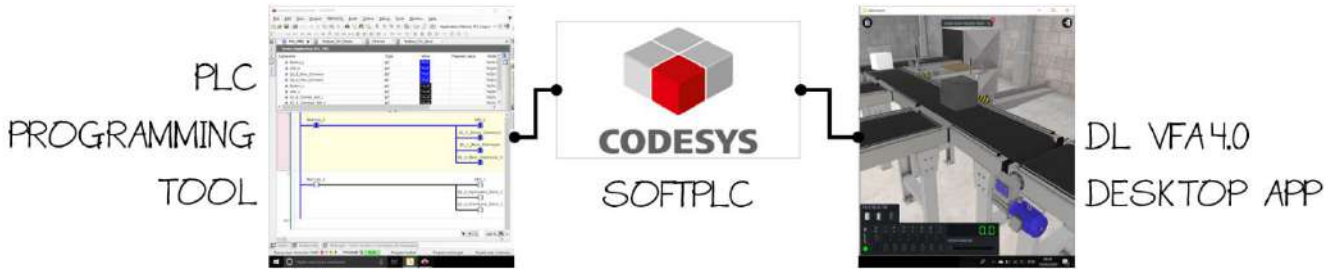


WHY DOES IT KEEP STUDENTS ENGAGED?

The courses in DL VFA4.0 are gamified and problem-based. This means that at DL VFA4.0 students are not students. They are trainees in the engineering team of the factory. As trainees, they have many projects and problems to work on, just in the same way it would occur in a real life trainee program.

Therefore, by taking the student into a story that takes place in a virtual reality environment, we promote engagement and fun. In this way, the students feel challenged and motivated. This challenging environment is what increases the learning process effectiveness.

HOW DOES LICENSING WORK?

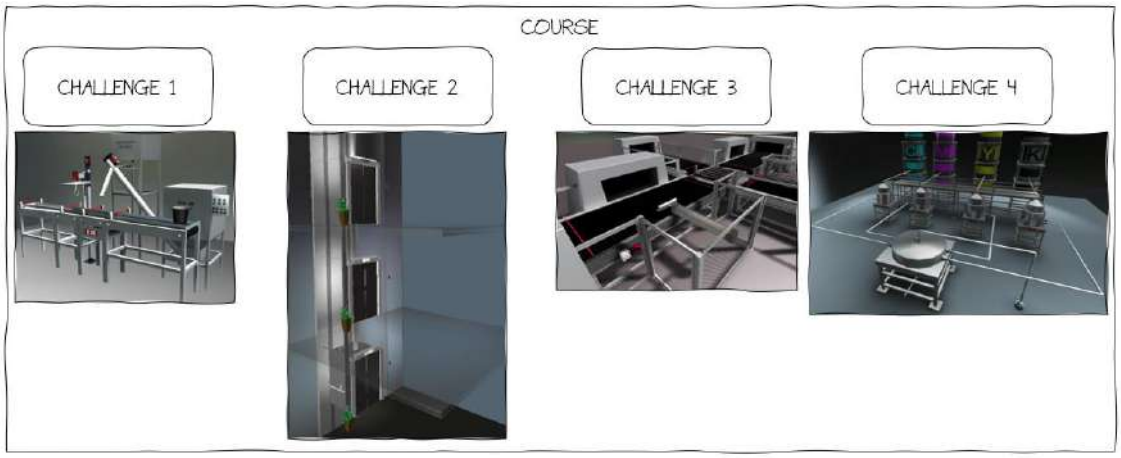
When the student logs in using the desktop app, the access is requested to DL VFA4.0 authentication server.

If the student is registered to a course, the server will grant him/her access to the platform and will update all the information needed. This means that the student may start the course at home and continue anywhere he/she is if the server is accessible through the internet.

HOW ARE COURSES STRUCTURED?

COURSES ARE STRUCTURED IN CHALLENGES

The courses are organized in challenges, which are mostly projects; every project takes place in a virtual reality environment. Before learning theory or receiving any instruction, the student receives a project to work on so he/she learns the purpose of it.



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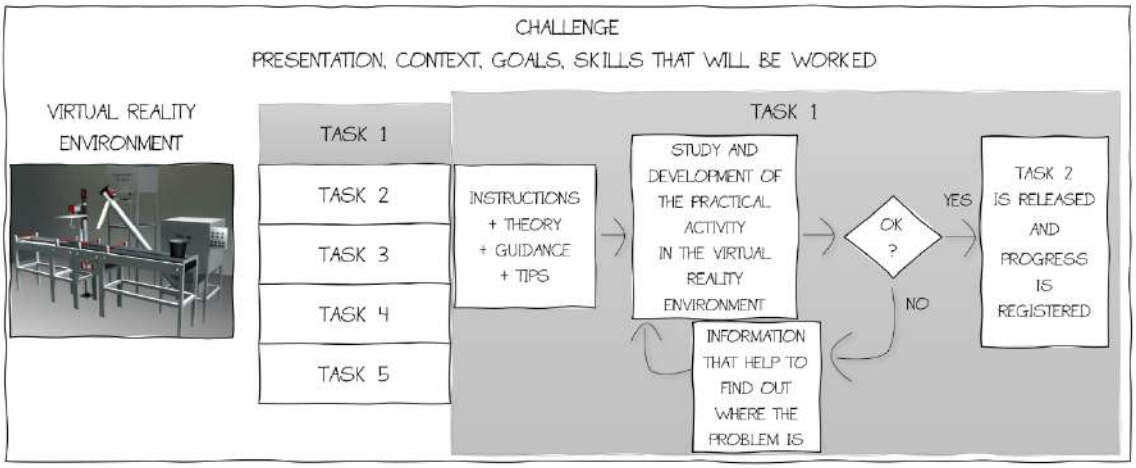
CHALLENGES ARE STRUCTURED IN TASKS

Every challenge is divided into small tasks, which are mostly steps to develop the project. in this way, the student develops the whole project by working on the small tasks.



Every small task includes instructions, theory, guidance and tips to reach the solution. The student though works on it, simulates, tests and tries to deliver by pressing the “delivery” button in the platform. In that moment, the platform tests the student’s solution in real time.

If the student’s solution meets the requirement of the task, the student is allowed to access the next task. If not, he/she receives information that help to identify where the problem is.

TASKS ARE AUTOMATICALLY VALIDATED

AUTOMATIC VALIDATION refers to the fact that in this platform, tasks are automatically validated and this is one of the most important features in DL VFA4.0. We can validate a task, if the student really developed the practical activity with success, without the need for the teacher to be watching videos, reading source codes, any other deliverable analysis.

This feature let the student proceed with the course in he/she own time and speed. This aspect allows teachers to save precious time; in this way, one teacher can support more students and yet he/she has time to improve the course.

HOW CAN IT HELP EDUCATIONAL SCHOOLS?

REPLACEMENT OF PRESENTIAL DISCIPLINES BY DISTANCE LEARNING ONES

In this moment of human personal interaction restrictions, schools may replace presential disciplines and courses by e-learning based ones, such as:

- Regular technical, graduation or post-graduation disciplines
- Extension courses
- Professional qualification courses

By doing that, the school may carry on with the courses without wasting time and, most important, maintaining or even increasing the quality.

BENEFIT FROM WORLDWIDE EVOLUTION

De Lorenzo is taking DL VFA4.0 all around the world. Our goal is to cover all practical disciplines in technical and engineering courses in the next years. Proceeding with the update and maintenance services, schools will receive every new feature and course integrated to DL VFA4.0, and they will take advantage of every improvement coming from the suggestions and requirements of worldwide users.

HOW DOES IT SAVE TEACHERS' TIME?

1. VALIDATION OF AUTOMATIC ACTIVITIES

As you can understand from the previous pages, the learning process is mostly automated in DL VFA4.0, including the validation of practical activities. This is the main point on it! Without this resource, the teacher would need to receive student's practical activities' deliverables in videos, software source-codes, PowerPoint presentations and so on. That would mean hours and hours evaluating material and grading it.

2. ANSWER SUGGESTIONS TO THE TEACHER

The Query&Answer system was developed to save the teacher's time. This is possible because the teacher may use his monitors' help to answer students' questions, keeping the responsibility to review and accept/reject them.

HOW DOES IT REDUCE COST?

1. BUILT-IN COURSES

There are built-in courses at DL VFA4.0 and there will be more along with the time. In this way, the school may adopt and improve them instead of building new ones.

One important point about the built-in courses is that they are reliable and have been used in other schools' disciplines of graduation or pos-graduation in engineering. So they are validated courses that have been used and improved from students' feedbacks.

2. VIRTUAL REALITY ENVIRONMENTS

The school may build new courses using all the virtual reality environments available and by keeping.

3. CONTINUOUS EVOLUTION WORLDWIDE

De Lorenzo is taking DL VFA4.0 all around the world. Our goal is to cover all practical disciplines in technical and engineering courses in the next years. Following the update and maintenance services, schools will receive every new feature and course integrated to DL VFA4.0, and they will take advantage of every improvement that is made from the suggestions and requirements of worldwide users.

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HOW DOES IT WORK ON THE PERSPECTIVE OF TEACHERS?

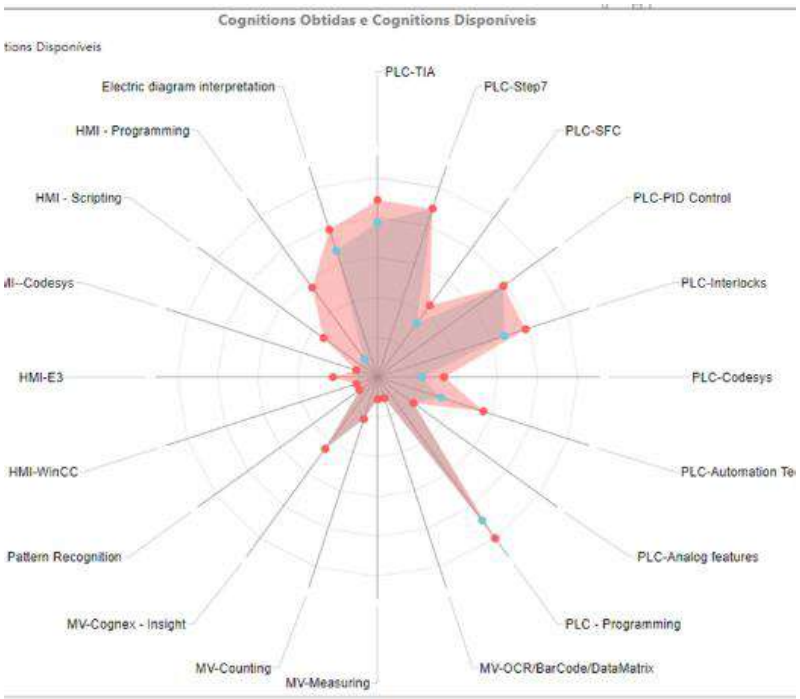
The teacher's role is related to supporting the students on the development of the activities, the management of the groups, identifying intervention actions, and finding opportunities for the improvement of courses.

LOW EFFORT IN SUPPORTING STUDENTS

It is important to say that the teacher's effort is very low in supporting students because the courses provide most of what students need. Built-in courses have been improved from students and teachers' suggestions and recommendations. In other words, questions coming from students are used to enrich the contents in order to avoid new questions whilst statistics are used to improve the courses.

PORTAL WITH DASHBOARDS AND ANALYTICS

The teacher can do and access everything the student can. Besides, he/she can also access the dashboard's portal. It includes interesting reports and analytics that help the teacher to monitor the group in real time, as well as to identify students who are doing very well, as well as those who need help, who are not working at all and who seem to be "cheating".



Skills radar chart

With this resource, the teacher may verify the progress of a group or a single student, considering what the course offers and what the students have worked on.

The lighter area regards to what the course offers.

The darker area, to what the student has already worked on.

The picture shows a student who has done almost everything.

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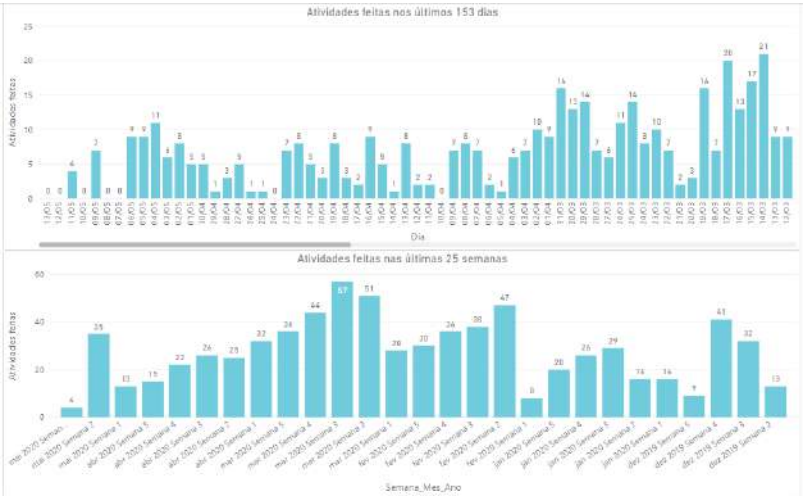
Curso	Controle de Processos		Visão Artificial	
Aluno	Atividades feitas	Mínimo atividades	Atividades feitas	Mínimo atividades
anonymized	12	27		
anonymized	39	27	7	5
anonymized	39	27	7	5
anonymized	39	27		
anonymized	39	27	7	5
anonymized	1	27	7	5
anonymized	30	27	1	5
anonymized	11	27	7	5
anonymized	27	27		
anonymized	12	27	7	5
anonymized	9	27	7	5
anonymized	39	27	7	5
anonymized	39	27	7	5
anonymized	39	27	7	5
anonymized	33	27	7	5
anonymized	39	27	7	5
anonymized			7	5
anonymized	39	27	7	5
anonymized	36	27	7	5
Total	39	27	7	5

Curso	Tarefa	Timestamp	IsDon
Scripts	1.1 - Abrindo uma tela modal	3/9/2020 6:33:37 PM	False
Desenvolvimento de sistemas supervisórios	2.6 - Implementar Gráficos	11/22/2019 7:14:00 PM	False
Desenvolvimento de sistemas supervisórios	2.5 - Montar interface principal	11/18/2019 5:04:15 PM	True
Desenvolvimento de sistemas supervisórios	2.4 - Construindo os objetos da aplicação	11/18/2019 4:28:54 PM	True
Desenvolvimento de sistemas supervisórios	2.3 - Explorando Recursos	11/15/2019 5:35:44 PM	True
Desenvolvimento de sistemas supervisórios	2.2 - Conhecendo o Elipse E3	11/15/2019 5:10:00 PM	True
Desenvolvimento de sistemas supervisórios	2.1 - Comunicação OPC	11/14/2019 12:57:42 PM	True
Desenvolvimento de sistemas supervisórios	1.8 - Comandos pelo supervisório	11/14/2019 11:25:14 AM	True
Desenvolvimento de sistemas supervisórios	1.7 - Implementando alarmes	11/8/2019 7:33:30 PM	True
Desenvolvimento de sistemas supervisórios	1.6 - Implementar Gráficos	11/7/2019 12:40:45 PM	True
Desenvolvimento de sistemas supervisórios	1.5 - Montar interface principal	11/5/2019 1:29:53 PM	True
Desenvolvimento de sistemas supervisórios	1.4 - Construir os objetos de Aplicação	11/4/2019 1:45:32 PM	True



Course approval summary

With this interface, the teacher may choose which disciplines and groups he/she wants to monitor, to verify who is passed, who is pending and so on.

It is possible to define the approval percentage in relation to the tasks available in the course.

Tasks report

This is an important tool since it provides evidence of the activities a student worked on.

That means the school has evidence of the practical activities the distance learner has done with detailed information about it.

Rhythm

This other dashboard shows the number of activities the students did daily and weekly.

The teacher may decide to verify it regarding a whole group/class or a specific student.

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Aluno	Atividades feitas	Duracao Total (h)	Tarefas por Hora
anonymized	39	36.31	1.07
anonymized	39	38.59	1.01
anonymized	39	38.48	1.01
anonymized	39	57.48	0.68
anonymized	39	60.15	0.65
anonymized	39	23.45	1.66
anonymized	39	74.54	0.52
anonymized	39	41.56	0.94
anonymized	39	78.83	0.49
anonymized	39	38.66	1.01
anonymized	39	62.22	0.63
anonymized	36	74.78	0.48

Effort/time per course

The image shows how many hours each student took to finish the course.

Tempo por tarefa

Tarefa	Duracao Total (h)
Controlador ON-OFF - Forno	4.33
Estudando a Planta - Forno	4.08
Controlador PI - Forno	3.14
Resposta transiente e estacionária - Forno	2.50
Estudando a planta - Fuso	2.45
Métodos de Ziegler-Nichols(Malha Fechada) - Forno	2.35
Controlador PD - Forno	1.99
Controlador ON-OFF - Válvula	1.88
PID Siemens - Forno	1.63
Controlador Proporcional - Forno	1.44
Controlador PI - Válvula	1.42
Métodos de Ziegler-Nichols(Malha Aberta) - Forno	1.29
Estudando a planta - Vávula	1.22
Resposta transiente e estacionária - Fuso	0.90
Controlador PID - Forno	0.90
Auto Ajuste - Forno	0.85
Controlador ON-OFF - Fuso	0.71
Controle em malha aberta - Fuso	0.61
Controlador PD - Fuso	0.37

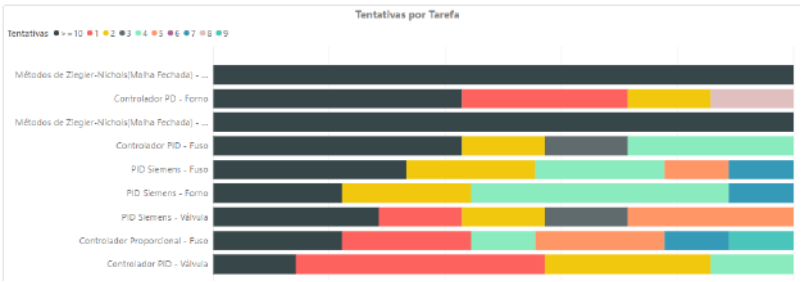
Effort/time per task

If the teacher selects a student, he/she may verify how much time the student took to develop and deliver each task of the course.

TasksDone X TimeTaken

Itis also possible to verify the distribution of the dedicated time with relation to the number of tasks done by each student at any period of time.

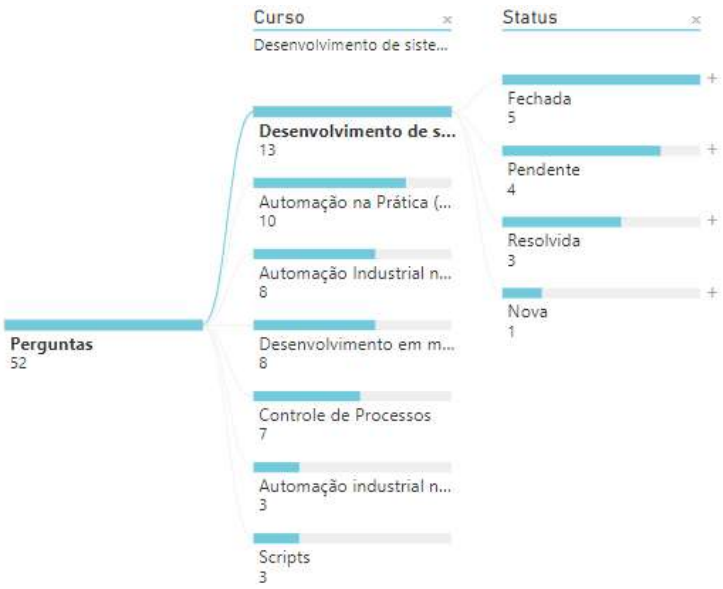
That helps to identify who is doing well, who may need help, who is doing nothing and who is trying to cheat.



Delivery trials per task

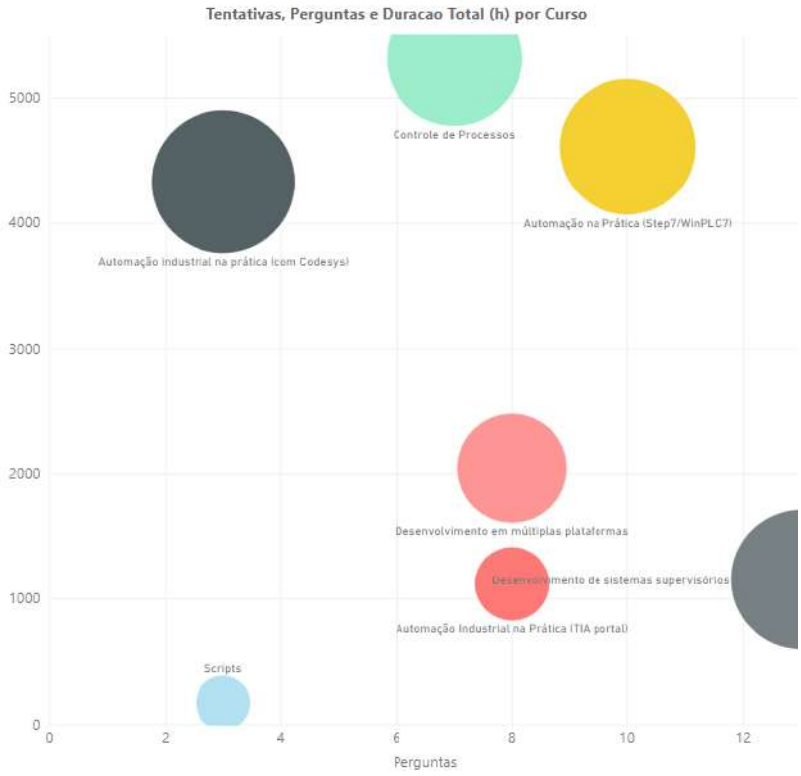
This chart helps the teacher to understand which task may be the most difficult and which one may be the easiest in

order to adjust the balance of the tasks in the course.



Query&Answer Stats

The teacher may also follow the Query&Answer numbers, in order to verify how many new questions have been made, how many are pending and so on.



Questions X Course Size

Itis also possible to verify the relation between the number of questions made by students regarding the number of tasks in the courses. Therefore, it is possible to verify which courses are demanding more attention of teachers to answer questions.

This interesting to drive effort to improve the instructions, theory and other contents in order to avoid doubts by the students.

PLATAFORMA E-LEARNING

COURSES SKILLS, MATERIALS, METHODS AND CONTENTS

MACHINE AUTOMATION

SKILLS / MAIN GOALS

At the end of this course the students will be able to develop automation systems for small machines with PLCs, using interlocks, sequencing and other approaches.

GAMIFIED CONTEXT (STORY)

In this course the student is a trainee at DL VFA4.0.

He/she learns that the DL VFA4.0 is an industrial enterprise with businesses in many sectors and is investing in industrial automation systems to increase its competitiveness.

The trainee (student) is required to develop automation projects and can receive all guidance, instructions and contents to study, in order to learn what is necessary to get the jobs done.

MATERIALS AND METHODS

Students will learn the contents by developing automation systems for machines and processes in the virtual environments. They will be provided with all the instructions, theory and contents required.

CONTENTS

- Historical context of automation
- Main concepts related to logic control
- Programmable logic controllers: hardware and software structure, technical characteristics and specifications, programming languages, main ladder instructions, data handling, numeric formats, maths, comparisons, timers and analog interfaces
- State machine (SFC) approach
- Electric diagram interpretation
- Electric commands for motor engines and pneumatic systems and their interfaces to PLCs

PLC TECHNOLOGY OPTIONS

In this course, the teacher may use tools such as Codesys Development, that is free, WinPCL7 that has demo and lite free versions, Simatic Manager, TIA Portal or Logix 5000. If the school decides to use a Rockwell or Siemens system, it will be necessary to provide licenses to the students.

Important note: TIA Portal can be downloaded and used fully operational for 21 days in trial mode, and it is possible for a student to do all the course in that time period if the student is dedicated exclusively to the course.

PLATAFORMA E-LEARNING

COURSE STRUCTURE (CHALLENGES)

CHALLENGE 1

AUTOMATING THE GATE OF FACTORY ACCOMODATIONS BUILDING

Project: the student is required to automate the door gate of the factory's accommodation. The reason is that the factory has plans to implement remote control for all its accesses

Tasks:

1) Open/Close while pressing 2 buttons
2) Using the end switches to avoid collision
3) Open/Close by pushing(impulse) 2 buttons
4) Interlocking to avoid short-circuit
5) Using the wall-button

Automation contents: automation and PLC basics, input and outputs, sensors and actuators, ladder language, basic ladder Boolean instructions: NO/NC contacts and simple coil, direct engine start and interlocks.

Electricity contents: basic electric automation panel, electric motor protection and command.

CHALLENGE 2

MANUAL OPERATION OF THE GYPSUM DOSING AND MIXING LINE

Project: the student receives a line from another factory but the PLC program is lost. Therefore, it is necessary to study the electric diagram and the description of how the machine works in order to develop a new system.
The student is required to work on the project in 2 phases: phase 1, manual operation, and phase 2, automatic operation. This challenge is phase 1.

Tasks:

1) Manual operations
2) 3 conveyors with 1 button
3) Adding water
4) Adjusting the conveyors

New automation contents: memory and image memory, PLC scan cycle, interlocks, retentive command instructions, sequencing techniques using interlocks and memories.

New electricity contents: complete automation and motor command electric panel, interpretation of the whole electric diagram, mapping the IO from the electric diagram.

CHALLENGE 3

AUTOMATION OF THE GYPSUM DOSING AND MIXING LINE

Project: the student is guided on the automation of the whole line using interlocks, memory, timers and dealing with the analog input to read the scale signal. He automates the sequencing step-by step in 8 tasks.

Tasks:

1) Transporting the recipient to the dosing station
2) Transporting the recipient to the mixing station
3) Filling the recipient
4) Moving the mixer up
5) Moving the mixer down
6) Turning the mixer on
7) Almost there (just a few adjusts)
8) Line 100% in automated

New automation contents: timers, counters, analog input signal reading and scaling, guidance on the use of memories and retentive commands.

New electricity contents: analog signal.

CHALLENGE 4

IMPROVE THE AUTOMATION SYSTEM OF THE GATE

Project: In this project the student must implement the automation of the gate so it can be opened, stopped or closed using a single push-button.

Tasks:

1) Opening and closing with 1 button
2) Adding the stop command
3) Adding the revert after stop feature

New automation contents: edge detection instructions, implement commands from impulse/pushes.

CHALLENGE 5

AUTOMATING THE LINE USING STATE MACHINES (SFC)

Project: the student is required to implement a new PLC software for the line but this time using SFC or state machine approach, in order to make it more flexible and easy to maintain. Final instructions are aimed to split the machine in 2 different state machines in order to allow simultaneous dosing and mixing operations, to increase the machine's performance.

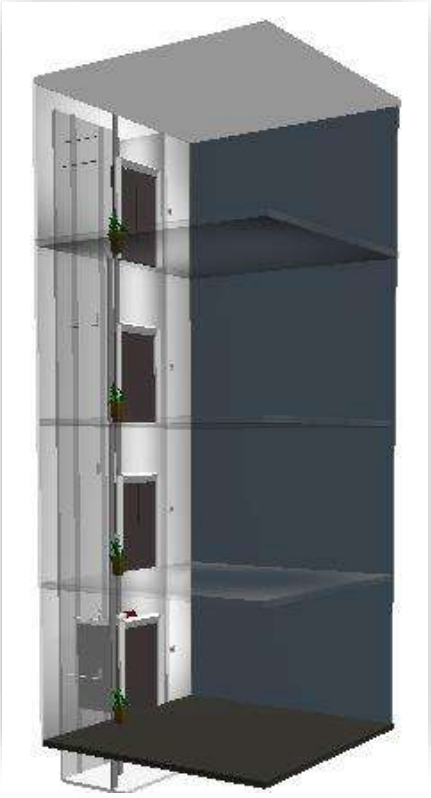
Tasks:

1) Designing an SFC Part 1: Steps and transitions
2) Designing an SFC Part 2: Actions
3) Improving the machine's performance
4) Implementing the SFC in Ladder
5) SFC solution to the dosing station
6) SFC solution to the mixing station
7) Machine 100% automated with SFC

New automation contents: state machines, SFC, implementation of SFC in ladder logic.

CHALLENGE 6

AUTOMATING THE FACTORY ELEVATOR



Project: the factory has vertical operation and needs to increase the number of elevators but instead of buying a new one, the factory decided to build it.
The student is required to develop the elevator's PLC software.

Tasks:

1) Designing a state machine for 2 floors
2) Addint the 3° floor
3) Using origin-destiny approach instead of SFC

New automation contents: when not to use state machines, linear movement with origin and destiny memory approach.

New electric contents: safety relays and circuit, interface between PLC and frequency inverters.

CHALLENGE 7

AUTOMATING THE INK COLORING PROCESS

Project: the student is required to develop a solution to automate color formulation in its ink factory. The student must use all the knowledge and skills developed to get this job done.

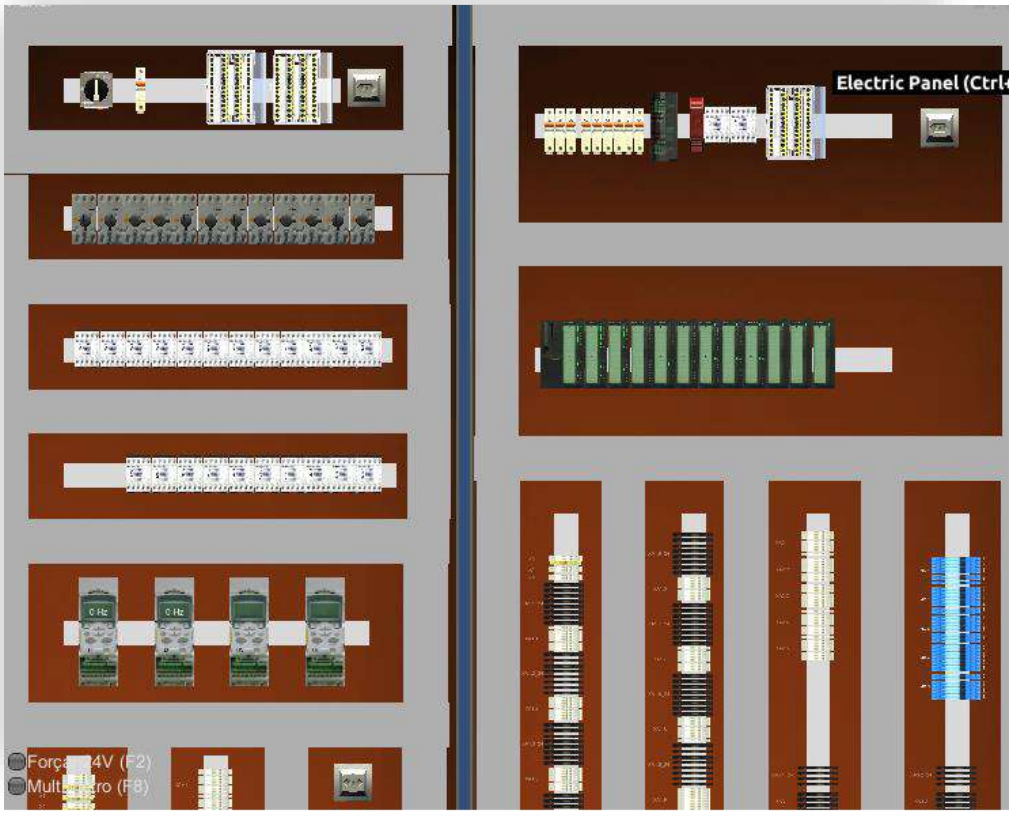
Tasks:

1) Creating a function block
2) Semi-automatic operation
3) Automatic operation

Automation contents: organization and function blocks, modularizing the project in small blocks, calling various instances of the same function block.

ELECTRIC PANEL

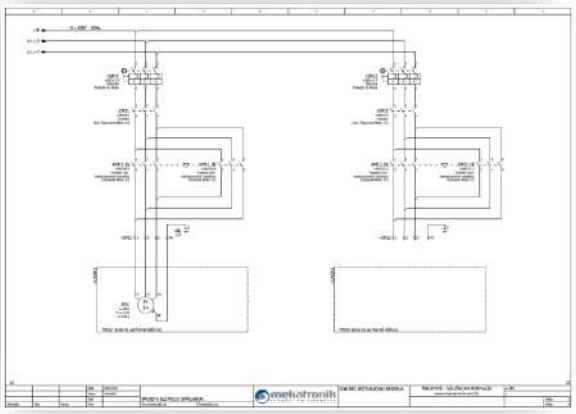
The image below shows an electric panel of one of the machines in the course. You may see that it is very similar to a real electric automation and motor command panel. It has the energy supply and protection, circuit breakers, contactors, safety relay, 24Vdc power supply, PLC, interface relays, connectors, contactors, frequency inverters and so on.

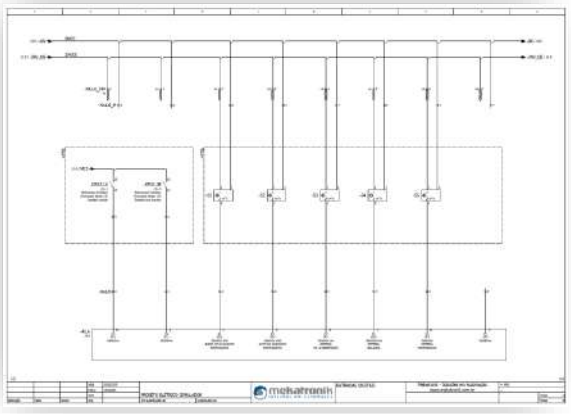


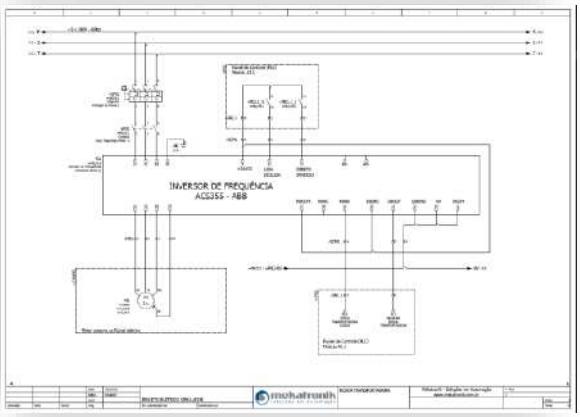
PLATAFORMA E-LEARNING

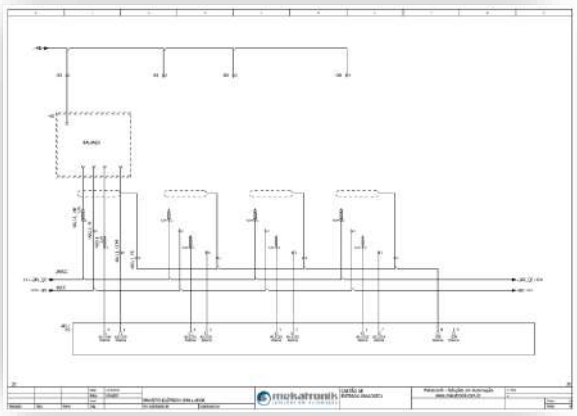
ELECTRIC DIAGRAM SAMPLES

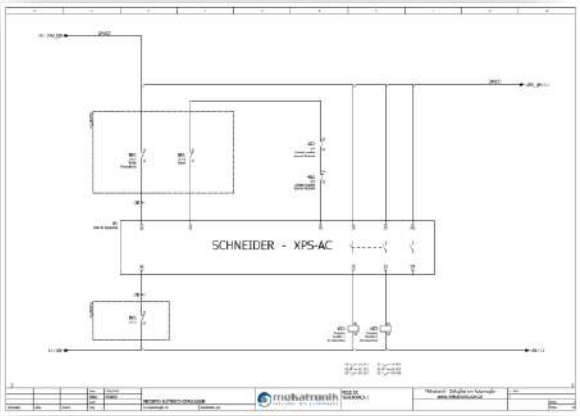
As well as the electric panel, the electric diagrams are also presented to the students in industrial standard. The following images are samples of the electric diagram pages. The left column refers to the electric motor command panel (forward/reverse motor direct start, frequency inverter start, safety relay), and the right column r to the PLC panel(digital input page, analog input page, output page).

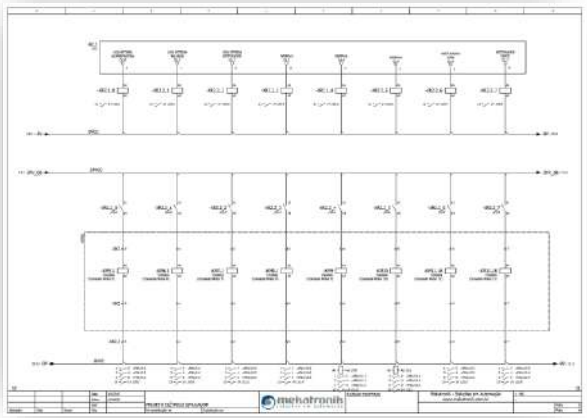










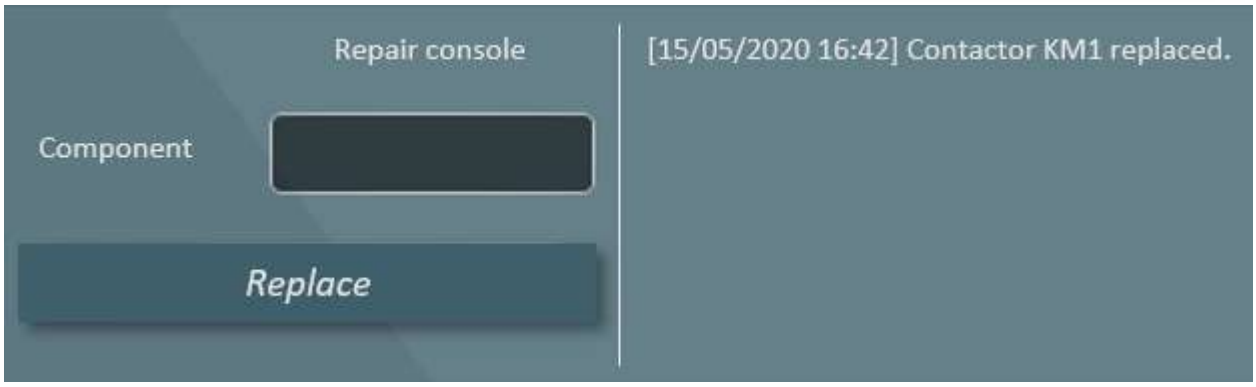


PLATAFORMA E-LEARNING

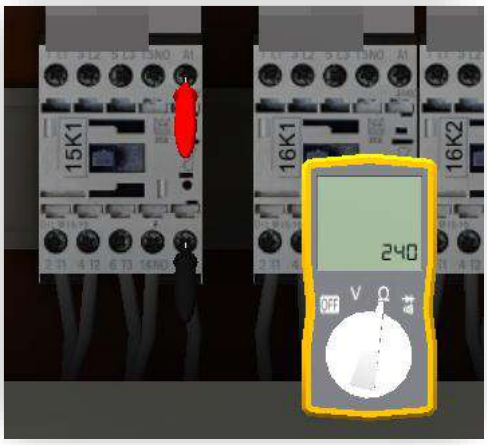
TROUBLESHOOTING

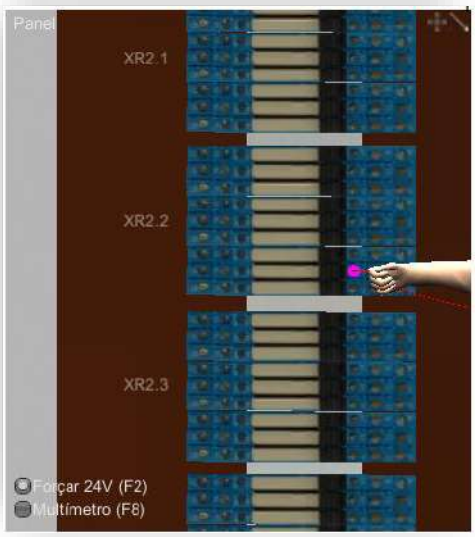
Solving problems on machinery quickly and effectively to reduce downtime is one of the most valued skills in industries. Our solution includes a resource (right image) to let the student activate a defect without knowing which defect it is. When the student does that, some component will be damaged and the machine will behave in some strange way.

The student's task is to find out the root cause of the problem and replace the damaged component by using the replacement console (image below).



In order to find out what the problem is, the student may use the virtual multimeter (left picture) to make measurements in the electric panel as well as force signal (right picture) to relay's coils in order to verify if actuators are working properly.

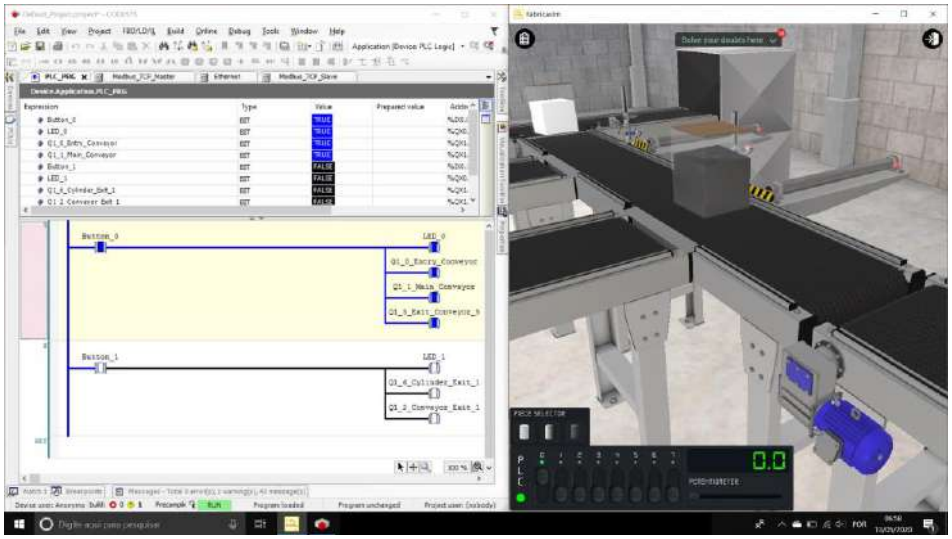




PLATAFORMA E-LEARNING

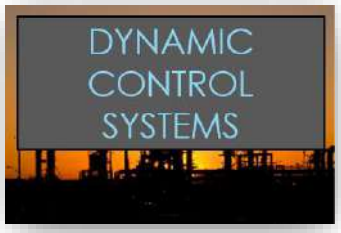
CHALLENGE/TASK VALIDATION

In the automation courses, the tasks are validated automatically by verifying if the machine's sequential behavior is in accordance with the requirements. The screenshot below shows a student's interface opened with DL VFA4.0 (right) and Codesys Development System (left)



PLATAFORMA E-LEARNING

PROCESS/DYNAMIC CONTROL SYSTEMS



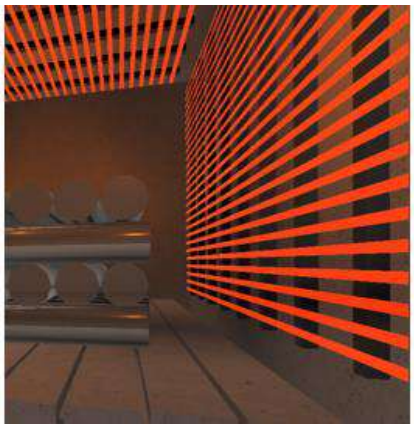
SKILLS / MAIN GOALS

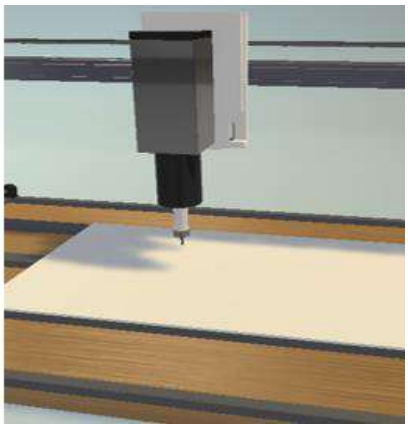
At the end of this course the students will be able to develop, integrate or improve PID controllers for dynamic systems.

GAMIFIED CONTEXT (STORY)

In this course, the student finds out that there are many opportunities to improve the factory results through better tuning of the PID controllers in machines and processes. Therefore, the team leader recommends studying and developing PID controllers to three tools that are available for tests.

These tools are three dynamic systems, each one with a different behavior: a valve (left), an electric furnace (middle) and a linear cursor (right). In the course, the student applies every concept, approach and technique learned in three different dynamic systems.





COURSE STRUCTURE (TOPICS AND CHALLENGES)

In this course, the student can control systems from the basics up to PID tuning and enhancement through analytical and experimental methods. In every challenge, the student must develop a solution for each of the three different systems in order to understand the differences between them and the difficulty level.

CHALLENGE 1. STUDYING AND EXPERIMENTING THE SYSTEMS: The student is requested to study the behavior of the 3 systems and try to keep them at specific points using a potentiometer. In the end, the student verifies that in one of them this task is easy. In another, it is not so easy and in one of them, it is impossible.

CHALLENGE 2. OPEN-LOOP CONTROL: The student implements an open loop control for the systems and finds out that it does not work well in every case.

CHALLENGE 3. TRANSIENT AND STEADY STATE RESPONSE: The student must run experiments and verify each system transient and steady state behavior.

CHALLENGE 4. ON-OFF CONTROL: The student must design and evaluate the response of an ON-OFF controller in each of the 3 systems.

CHALLENGE 5. PROPORTIONAL CONTROLLER: The student must design and evaluate the response of a proportional controller.

CHALLENGE 6. SIEMENS PID BLOCK: The student learns how to work with the Siemens PID Block and must implement a proportional controller using it for each of the 3 systems.

CHALLENGE 7. PI CONTROLLER: The student must design and evaluate the response of a proportional and integral controller.

CHALLENGE 7. PD CONTROLLER: The student must design and evaluate the response of a proportional and derivative controller.

CHALLENGE 7. PID CONTROLLER: The student must design and evaluate the response of a proportional, integral and derivative controller.

CHALLENGE 8. ZIEGLER-NICHOLS METHOD (CLOSED-LOOP): The student must use the Ziegler-Nichols method to tune a PID controller.

CHALLENGE 9. ZIEGLER-NICHOLS METHOD (OPEN-LOOP): The student must use the Ziegler-Nichols method to tune a PID controller.

CHALLENGE 10. OTHER PARAMETRIZATION METHODS: The student must tune PID controllers using other parametrization methods.

CHALLENGE 11. AUTO-TUNING: The student learns how to use the auto-tuning in the Siemens PID block.

PLC TECHNOLOGY OPTIONS

In this course, the teacher may use tools such as Codesys Development, that is free, WinPCL7 that has demo and lite free versions, Simatic Manager, TIA Portal or Logix5000. If the school decides to use a Rockwell or Siemens system, it will be necessary to provide licenses to the students.

Materials and methods:

Students will face practical situations in which they need to develop dynamic control systems with a PLC.

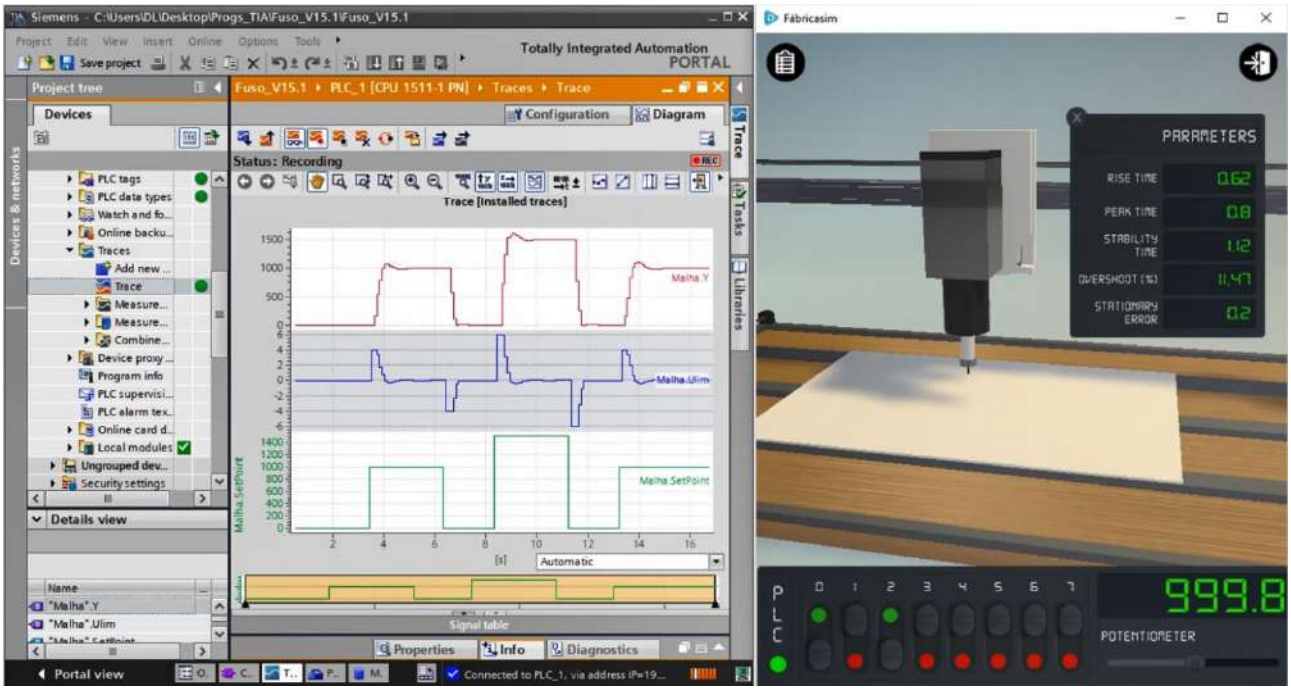
Contents

- Control systems: introduction, examples, block diagrams, open and close loop systems
- Control principles: mathematical modeling of dynamic systems, linearity, transfer function, block diagrams, frequency response, stability, computational simulation
- Control approaches: classic, optimal, fuzzy, other approaches
- ON-OFF and PID Control (P, PI, D, PID): designing and tuning by analytic and experimental methods, and study of the P, D and I control actions.
- Analysis of systems of first, second and third order in transitory and steady state

CHALLENGE/TASK VALIDATION

In the control course, most of the tasks are validated by verifying if the controller implemented by the student meets the requirements available in the instructions. As mentioned before, this is an automatic mechanism, so the platform gives feedback to the student about his applications results.

As you can see in the picture, in the left side the Siemens TIA portal is opened. The student has already developed his software and at the time of the screenshot, the student was testing the application and using the TIA trace feature.



PLATAFORMA E-LEARNING

SCADA SYSTEMS DEVELOPMENT

SKILLS / MAIN GOALS

At the end of this course, the students will be able to develop SCADA systems for automatic machines and processes with resources such as synoptics, alarm summary, trends and so on.

GAMIFIED CONTEXT (STORY)

In this course, the student finds out that there are many opportunities to improve the factory's results through better tuning the PID controllers in machines and processes. Therefore, the team leader recommends studying and developing PID controllers to three tools which are available for tests.

TECHNOLOGY OPTIONS

In this course, the student will be presented to 3 tools: Codesys Visualization, Elipse E3 and Siemens Wincc. Codesys is free. Elipse E3 and Siemens WinCC are payed software but they have trial versions. The Elipse E3 Demo works forever but with a tag limitation which brings no problem to the course progress. The WinCC trial runs fully operational for 21 days, so the student must install and work on the challenge with WinCC in at most 21 days in order to finish within the trial period.

MATERIALS AND METHODS

Students will learn the contents by developing SCADA systems for machines and processes and simulating them in DL VFA4.0 virtual environments.

Contents

- SCADA systems: brief historical context, main concepts,
- Structure: hardware and software components, interaction to controllers and other systems, communication drivers and OPC servers.
- Programming environment and tools and its main features and resources: tags, screens, user interface components, real-time databases, trends, historical data recording and exhibition, animation, user management.
- Development of projects: understanding the project requirements, planning the system, defining architecture, develop, test and validate.

CHALLENGE/TASK VALIDATION

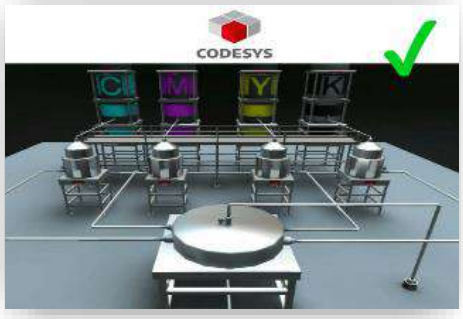
In the SCADA course, the students are required to answer to questions in forms, as well as to upload small videos with limited duration, and attach the link when delivering the tasks.

PLATAFORMA E-LEARNING

COURSE STRUCTURE (CHALLENGES)

CHALLENGE 1

A SCADA SYSTEM WITH CODESYS VISU



Project: the student is required to develop a SCADA system for the ink coloring process using the SCADA system Codesys VISU. The reason is that the factory plans to build a control room for the operation of all its processes and machines.

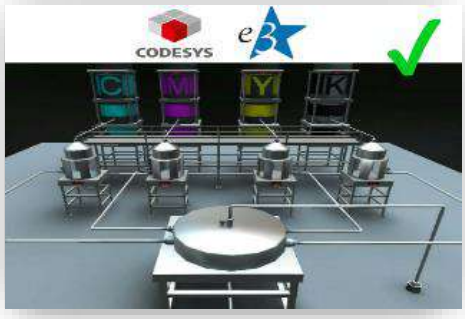
Tasks:

1) Understanding the application and its requirements
2) Understanding the Codesys Visu
3) Exploring resources and features
4) Building application objects
5) Implementing the main interface (synoptic)
6) Implementing charts/trends
7) Implementing alarm summary
8) Operating the process with the SCADA system

Automation contents: Codesys Visualization and WebVisu SCADA development tool, screens, user interface objects, navigation, charts/trends, alarm summary, tags, variables.

CHALLENGE 2

A SCADA SYSTEM WITH ELIPSE E3



Project: the student is required to develop a SCADA system for the ink coloring process using the SCADA system Elipse E3. The reason is that the factory plans to build a control room for the operation of all its processes and machines.

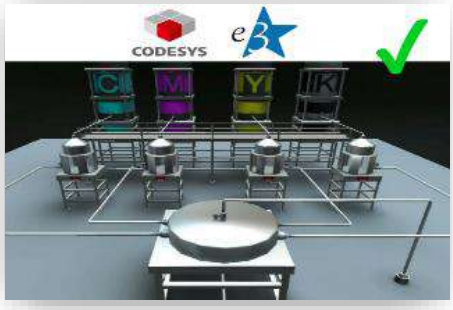
Tasks:

1) OPC communication
2) Elipse E3 environment
3) Exploring resources and features
4) Building application objects
5) Implementing the main interface (synoptic)
6) Implementing charts/trends
7) Implementing alarm summary
8) Operating the process with the SCADA system

New automation contents: OPC Server, Elipse E3, features, screens, tags, navigation, interface objects, charts/trends, good practices.

CHALLENGE 3

IMPROVING THE SOLUTION WITH ELIPSE E3



Project: the student is required to implement new features to the SCADA system for the ink coloring process using the SCADA system Elipse E3, in order to enhance operation and security of the process.

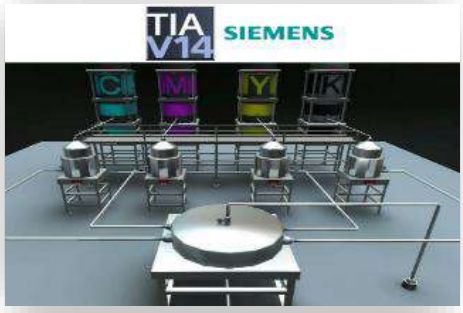
Tasks:

1) User management
2) Optimizing/saving tags
3) Implementing recipe management

New automation contents: users, recipes and scripting.

CHALLENGE 4

A SCADA SYSTEM WIN SIEMENS WINCC



Project: the student is required to develop a SCADA system for the ink coloring process using the SCADA system WinCC.

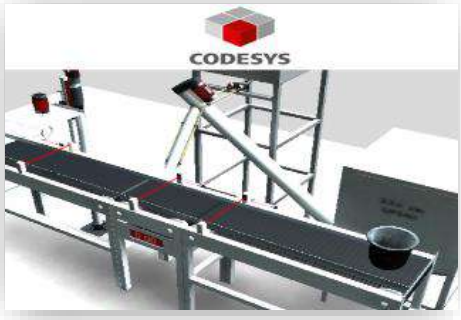
Tasks:

1) WinCC basics
2) Exploring resources and features
3) Implementing visualizations
4) Implementing operation features
5) Implementing charts and trends
6) Implementing user management
7) Implementing alarms and alerts
8) Recipe management

New automation contents: WinCC basics, features, screens, tags, navigation, interface objects, charts/trends, good practices, users, recipes, scripting.

CHALLENGE 5

A SCADA SYSTEM FOR THE DOSING AND MIXING LINE



Project: the student is required to develop a SCADA system for the dosing and mixing line. The student may choose any one of the SCADA systems he learned how to work with.

Tasks:

1) Implementing the SCADA system

New automation contents: none.

PLATAFORMA E-LEARNING

MACHINE VISION SYSTEMS

Skills

At the end of this course, the students will be capable of integrating machine vision systems to recognize patterns, measure, count and identify presence/absence of components in parts, as well as read bar codes, datamatrix and OCRs.

GAMIFIED CONTEXT (STORY)

In this course, the students are in a furniture factory and they need to develop machine vision systems to assure that 1) furniture parts are 100% compliant with the design measures, 2) the accessories to assembly the furniture are delivered in the correct quantities, and 3) all furniture kit boxes tags are read to be tracked:

TECHNOLOGY OPTIONS

In this course, the student will be presented to the COGNEX In Sight tool, one of the world leaders in machine vision for industry. The Cognex In Sight may be download and used by the students just by requesting a free trial license in the website.

MATERIALS AND METHODS

Students will learn the contents by developing machine vision systems for production lines and simulating them in DL VFA4.0 virtual environments.

In the course, the students will face the most common challenges in developing a machine vision system.

CONTENTS

- Computational vision: cameras, illumination, colors
- Methods of filtering and imaging
- General concepts and standards
- Edge detectors
- Tools to detect positioning, recognize patterns, count, measure and read codes

CHALLENGE/TASK VALIDATION

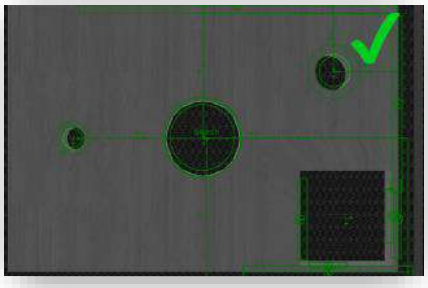
In the Machine Vision course, the platform automatically validates each task by comparing the inspection results of the student's application with the correct values of the process.

PLATAFORMA E-LEARNING

COURSE STRUCTURE (CHALLENGES)

CHALLENGE 1

REAL TIME MEASUREMENT INSPECTION



Project: the student is required to implement a measurement system to inspect furniture parts in real time, in a live production line.

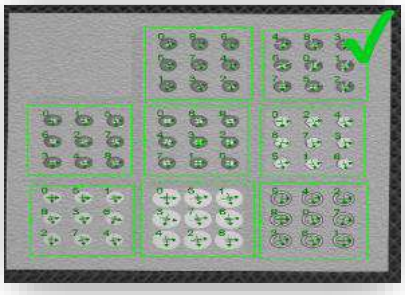
Tasks:

1) Measuring tools
2) Validating with the standard

Automation contents: Cognex In-Sight system, system set-up, positioning, using the spreadsheet, calibration, measurement tools, and inspection validation.

CHALLENGE 2

COUNTING COMPONENTS



Project: the student is required to implement a machine vision system using Cognex In-Sight to inspect if specific assembly components are provided in the correct quantities with the furniture.

Tasks:

1) Counting a individual component groups
2) Counting everything

New automation contents: pattern recognition, counting.

CHALLENGE 3

READING TAGS

Project: The student is required to implement a machine vision system to read the tag on the furniture box in order to keep tracking of them.

Tasks:

1) Reading data matrix
2) Reading OCR
3) Validating the tag

New automation contents: OCR, bar code, data-matrix reading tools.

PLATAFORMA E-LEARNING

SCRIPTS IN SCADA SYSTEMS

Skills

At the end of this course, the students will be able to develop scripts for SCADA systems to implement features that are not provided natively by the SCADA platform.

GAMIFIED CONTEXT (STORY)

In this course, the students are required to improve a SCADA system in the factory by implementing features that are not natively offered by the SCADA platform. Those features are referred to better user management, UI/UX.

TECHNOLOGY OPTIONS

In this course, the student will be presented to Elipse E3 and Siemens WinCC. Elipse E3 and Siemens WinCC are payed softwares but they have have trial versions. The Elipse E3 Demo works forever but with a tag limitation which brings no problem to the course progress. The WinCC trial runs fully operational for 21 days, so the student must install and work on the challenge with WinCC in at most 21 days in order to finish within the trial period.

Skills on developing SCADA systems is a requirement for this course.

MATERIALS AND METHODS

Students will learn the contents by developing scripts for several applications such as user management, multi-instance modal screens, data storage and retrieve, watchdog and others.

Contents

- Programming languages
- Algorithms
- Code structuring in functions
- Visual basic for applications (VBA)
- VBScript

CHALLENGE/TASK VALIDATION

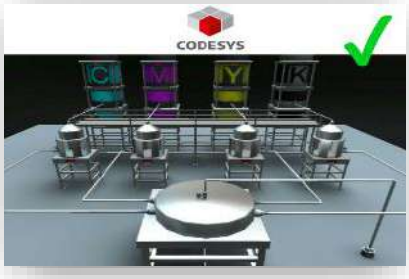
In the SCRIPTs course, the students are required to answer questions in forms, as well as to upload small videos with limited duration, and attach the link when delivering the tasks.

PLATAFORMA E-LEARNING

COURSE STRUCTURE (CHALLENGES)

CHALLENGE 1

MODAL SCREEN UI/UX



Project: the student must implement a feature to open modal screens in the most suitable position to offer better usability and user experience.

Tasks:

1) Opening a modal screen
2) Positioning by the mouse coordinates
3) Improving positioning
4) Passing parameters

Automation contents: basics of VBScript, if, else, case.

CHALLENGE 2

SAFE OPERATION IN MULTI USER SCADA SYSTEM

Project: the student is required to implement feature to define the operators who are responsible for operating specific machines, so that one operator will not operate the wrong machine by mistake. It is necessary because the same SCADA system is used by many operators to run different machines.

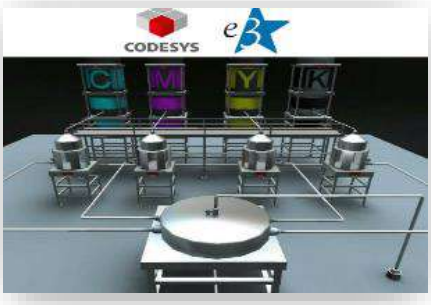
Tasks:

1) Identifying the operator
2) Building the interface
3) Enabling the safe operation

New automation contents: user management, for, while.

CHALLENGE 3

EXTRA FEATURES



Project: The student is required to some extra features that increase the SCADA system's reliability.

Tasks:

1) Watchdog
2) Alarm filters
3) Instructions when alarms occur
4) UI/UX resources
5) General resources

New automation contents: specific scripts for each feature

PLATAFORMA E-LEARNING

AUTOMATION OF SYSTEMS WITH MULTIPLE SUBSYSTEMS

Skills

At the end of this course, the students will be able to develop automation systems for machines and/or processes that are composed of several subsystems.

GAMIFIED CONTEXT (STORY)

In this course, the student needs to develop an automation system for an automatic warehousing system with 10 columns and 5 floors. To do that, the student will learn how to divide the project in small functional parts, implement their unitary controls and integrate everything.

TECHNOLOGY OPTIONS

In this course, the teacher may use tools such as Codesys Development, that is free, WinPCL7 that has demo and lite free versions, Simatic Manager, TIA Portal or Logix5000. If the school decides to use a Rockwell or Siemens system, it will be necessary to provide licenses to the students.

Important note: TIA Portal can be downloaded and used fully operational for 21 days in trial mode, and it is possible for a student to do all the course in that time period if the student is dedicated exclusively to the course.

MATERIALS AND METHODS

Students will learn the contents by developing automation systems for equipment with interconnected and interlocked subsystems. They will be provided with all the instructions, theory and contents required.

Contents

- Processes, machines and systems
- Splitting a machine in several smaller machines
- Structuring the application in function blocks
- Using parametric function blocks
- Develop of a system with subsystems
- Organization, structuring and good practices
- Programmable controllers: counters, multibit instructions, libraries and function blocks, analysis and diagnostic resources.

CHALLENGE/TASK VALIDATION

In this course, the students are required to answer questions in forms, as well as to upload small videos with limited duration, and attach the link when delivering the tasks.

PLATAFORMA E-LEARNING

COURSE STRUCTURE (CHALLENGES)

CHALLENGE 1

SEMI-AUTOMATIC OPERATION OF THE WAREHOUSE SYSTEM

Project: the student is required to develop a solution to enable semi-automatic operation of the equipment.

Tasks:

1) Understanding the application
2) Initial organization
3) Manual operation
4) Moving to pre-defined positions
5) Moving with speed control
6) Moving to user-defined positions

Automation contents: indirect addressing, inspection of objects, POUs, IEC61131-3, function X functional block, multibit operations.

CHALLENGE 2

SAFE OPERATION IN MULTI USER SCADA SYSTEM

Project: the student is required to implement feature to define the operators who are responsible for operating specific machines, so that one operator will not operate the wrong machine by mistake. It is necessary because the same SCADA system is used by many operators to operate different machines.

Tasks:

1) Supplying and shipping
2) Handling
3) Semi-automatic operation
4) Automatic operation

New automation contents: multi-instances of functional blocks, positioning approaches.

PLATAFORMA E-LEARNING

THIRD PART SOFTWARE VERSIONS AVAILABILITY

The list below includes the third part softwares that may be used by the students and professors during the courses. The manufacturers' websites are listed. It's the institution's responsibility to verify the licensing terms for each one of them.

	FREE VERSION	TRIAL OR DEMO	PAYED EDUCATIONAL VERSION
CODESYS DEVELOPMENT SYSTEM V3	YES Runtime stops after 2 hours but may be restarted indefinitely.		
WINPLC7 LITE		YES Limited number of instructions per cycle in simulation mode.	YES
TIA PORTAL		YES Runs without any limitation for 21 days	YES
ELIPSE E3		YES Application is limited to 20 tags.	YES
COGNEX INSIGHT	User must require a Key Code at Cognex Website		NO INFORMATION AVAILABLE IN THE WEBSITE

PLATAFORMA E-LEARNING

SYSTEM REQUIREMENTS

SYSTEM REQUIREMENTS	MINIMUM	RECCOMMENDED
PROCESSOR	i5	i7
RAM MEMORY	8GB	16GB
GRAPHIC BOARD	-	2GB
OPERATIONAL SYSTEM	WINDOWS 10	WINDOWS 10 PRO

SUPPORT MATERIAL FOR PROFESSORS/INSTRUCTORS

The professor is provided with the solutions for all the tasks in the courses, as well as the documentation about every virtual process and machine, such as description, components, electric diagrams, list of failures available for troubleshooting practices.

DASHBOARDS

The dashboards are published using Microsoft PowerBI.

PLATAFORMA E-LEARNING

LICENCESES

According to the validity term you need and the number of licenses you want to purchase, you can consider the following codes of DL VFA4.0:

Code	Description
DL VFA4.0-100-6M	Virtual Factory Automation 1-100 licenses / 6 months validity
DL VFA4.0-100-1A	Virtual Factory Automation 1-100 licenses / 1 year validity
DL VFA4.0-100-5A	Virtual Factory Automation 1-100 licenses / 5 years validity
DL VFA4.0-500-6M	Virtual Factory Automation 101-500 licenses / 6 months validity
DL VFA4.0-500-1A	Virtual Factory Automation 101-500 licenses / 1 year validity
DL VFA4.0-500-5A	Virtual Factory Automation 101-500 licenses / 5 years validity
DL VFA4.0-1000-6M	Virtual Factory Automation 501-1000 licenses / 6 months validity
DL VFA4.0-1000-1A	Virtual Factory Automation 501-1000 licenses / 1 year validity
DL VFA4.0-1000-5A	Virtual Factory Automation 501-1000 licenses / 5 years validity
DL VFA4.0-10000-6M	Virtual Factory Automation 1001-10000 licenses / 6 months validity
DL VFA4.0-10000-1A	Virtual Factory Automation 1001-10000 licenses / 1 year validity
DL VFA4.0-10000-5A	Virtual Factory Automation 1001-10000 licenses / 5 years validity

DASHBOARD codes

Code	Description
DL VFADASH-6M	Dashboard for Virtual Factory Automation / 6 months validity
DL VFADASH-1A	Dashboard for Virtual Factory Automation / 1 year validity
DL VFADASH-5A	Dashboard for Virtual Factory Automation / 5 years validity