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MIND

Erasmus+ strategic partnership for Higher Education

DEVELOPMENT OF MECHATRONICS SKILLS AND INNOVATIVE LEARNING METHODS FOR INDUSTRY 4.0

IO4 REPORT

Project Title	**Development of mechatronics skills and innovative learning methods for Industry 4.0** **2019-1-RO01-KA203-063153**
Output	**IO4 – MIND Platform for learning new skills in mechatronics within the network for Industry 4.0**
Date of Delivery	**February 2021**
Authors	**The leader of this intellectual output is UPT and all the partners are implicated in the realization UTCN, UNI, UPT, CC, STU and IHR.**
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Contents

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1 Introduction, objectives, and tasks of IO4

Mechatronics represents a symbiosis of technical disciplines as mechanics, electronics, control systems and computer systems. The aim of mechatronics is to develop new concepts of equipment with built-in artificial intelligence algorithms.

The MIND project main goal is to develop mechatronics skills and innovative learning methods for Industry 4.0, to meet the requirements of the employers, in order to prepare qualified students with interdisciplinary skills in mechatronic, IT and superior soft skills for developing the concepts of Industry 4.0.

In developing of IO4 following all partners were involved.

The specific tasks of the IO4 are:

- Identify the functional requirements according to the target group needs.
- Elaborate the technical documentation: programming code, database.
- Create and validate a prototype by all partners.
- Testing and creation of the final version of MIND platform.

The platform for e-learning will focus on acquiring knowledge through practical problem solving and explaining real industrial applications, but not the classical methodologies of teaching by memorizing of knowledge.

“Learn by doing” is the key to success in new trends in mechatronics and in the technologies that are developed in concordance to the Industry 4.0.

The main goal of the MIND platform is to make an accessible and user-friendly learning platform, in order to encourage and support the students who want to learn new skills for mechatronics, which are suitable with Industry 4.0. By accessing the platform, the students will find a good, structured courses based on the requirements of the industrial partners, they can learn anywhere and in their own rhythm. For consolidating the acquired knowledge, the students can take a quiz in order to see, where improvements can be done or what gaps they have in the explained materials. Everyday training using MIND platform will guide the students to the right path to learn mechatronics and the technologies used in Industry 4.0 [WAN13].

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2 Requirements, according to target groups

Given the fact that the main target group is represented by the students willing to study or the ones who are already studying mechatronics, the first step that was made was to create a questionnaire for them. The students expressed their interest in having a more facile way to acquire necessary skills for the mechatronics students from Technical University of Cluj-Napoca and to have the ability to assess their knowledge in this area at the end of each part [MCB09].

Fig. 1 Implementation of teaching and assessment methods

After a brainstorming was done, where many teaching and assessment methods were considered for sharing with the students, the following were implemented, as shown in fig. 1:

- Online courses and toolkits on the most important topics
- Short videos on different mechatronics topics
- Quizzes as assessment methods based on the videos watched

Students need concrete, concluding and clear materials. If they want to study by themselves, they need to be able to understand and learn the fundamental notions in mechatronics [WEI13].

The requirements for the videos uploaded were to be short but concluding. The first part of the video is a short introduction of the topic discussed, followed by a practical demonstration of the equipment or the software implementation of the concept. After completing each video, the students have the possibility (if wanted) to complete a short quiz about the content they have watched. The quiz is meant to be simple, easy to complete and to give them an objective view of their acquired knowledge regarding the studied material. They always can watch the videos again if something is unclear and also to find more details in the courses.

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3 MIND platform

The online learning platform in mechatronics for Industry 4.0 is offering the following requirements:

- A large database of didactic and multimedia course topics in mechatronics that were generated by all the partner universities.
- The option of learning any topic of interest and have online verification tools.
- Possibility of tracking the progress of students by filling the questionnaire after finishing a module.

The platform will be hosted on the project website: https://www.project-mind.eu/index.php/platform

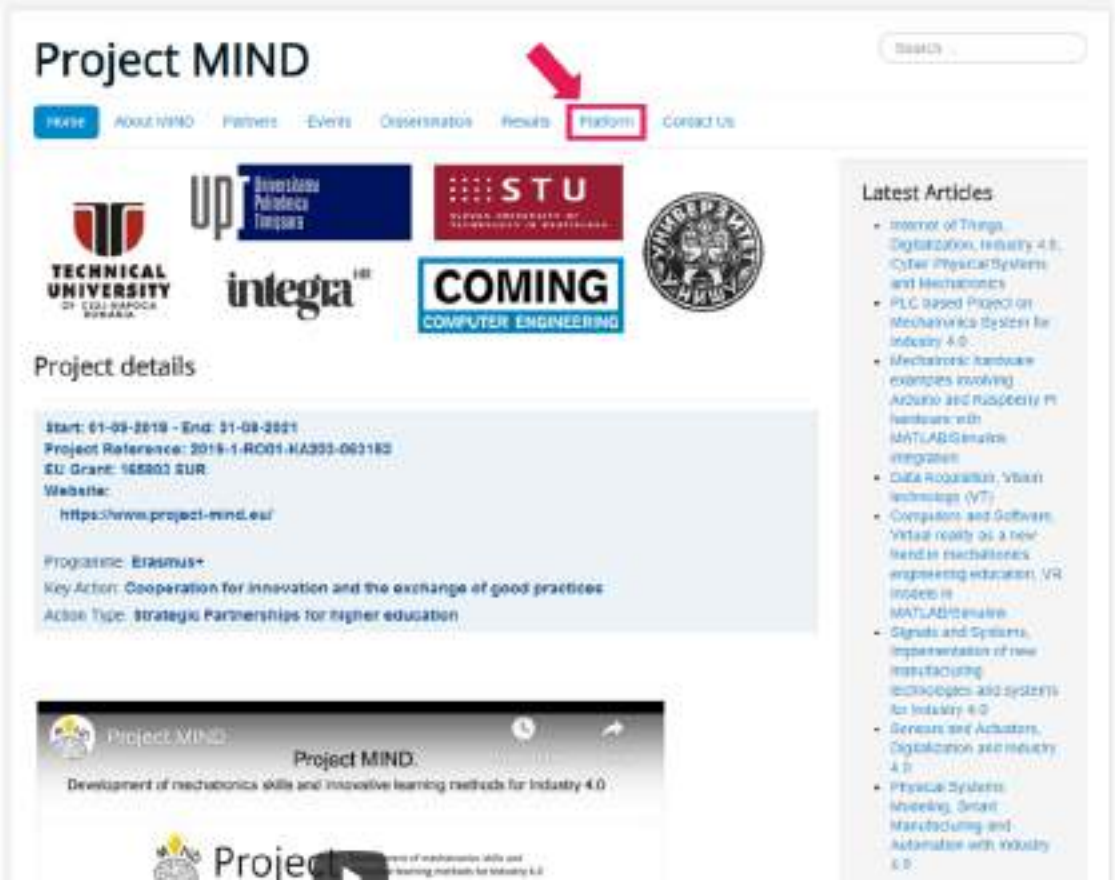

Fig. 2 MIND Platform tab

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The consortium has agreed that the MIND platform will cover following topics:

- Physical Systems Modeling, Smart Manufacturing and Automation with Industry 4.0
- Sensors and Actuators, Digitalization and Industry 4.0
- Signals and Systems, Implementation of new manufacturing technologies and systems for Industry 4.0
- Computers and Software, Virtual reality as a new trend in mechatronics engineering education, VR models in MATLAB/Simulink
- Data Acquisition, Vision technology (VT)
- Mechatronic hardware examples involving Arduino and Raspberry Pi hardware with MATLAB/Simulink integration
- PLC based Project on Mechatronics System for Industry 4.0
- Internet of Things, Digitalization, Industry 4.0, Cyber Physical Systems and Mechatronics

This module can be found on the platform section of the project website (Fig.3).

The platform is also based on the results of IO3 and IO3, what's why each module will consist of three parts. First part will represent a theoretical introduction and explanation of the topic, which was uploaded as a pdf file on the platform. The course can be read on the website, or the students also have possibility to download it, if they want to study it offline or they have some troubles with the internet connection.

For increasing the interest of the students some of the aspects explained in the written course will be covered in MIND videos, which are based on real-life systems and examples that are used in industry. The videos are short and only the important ideas, that need to be remembered, are displayed in the video.

The third part represents a questionnaire, so the students can test themselves in order to see what exact part of the presented material was unclear to them.

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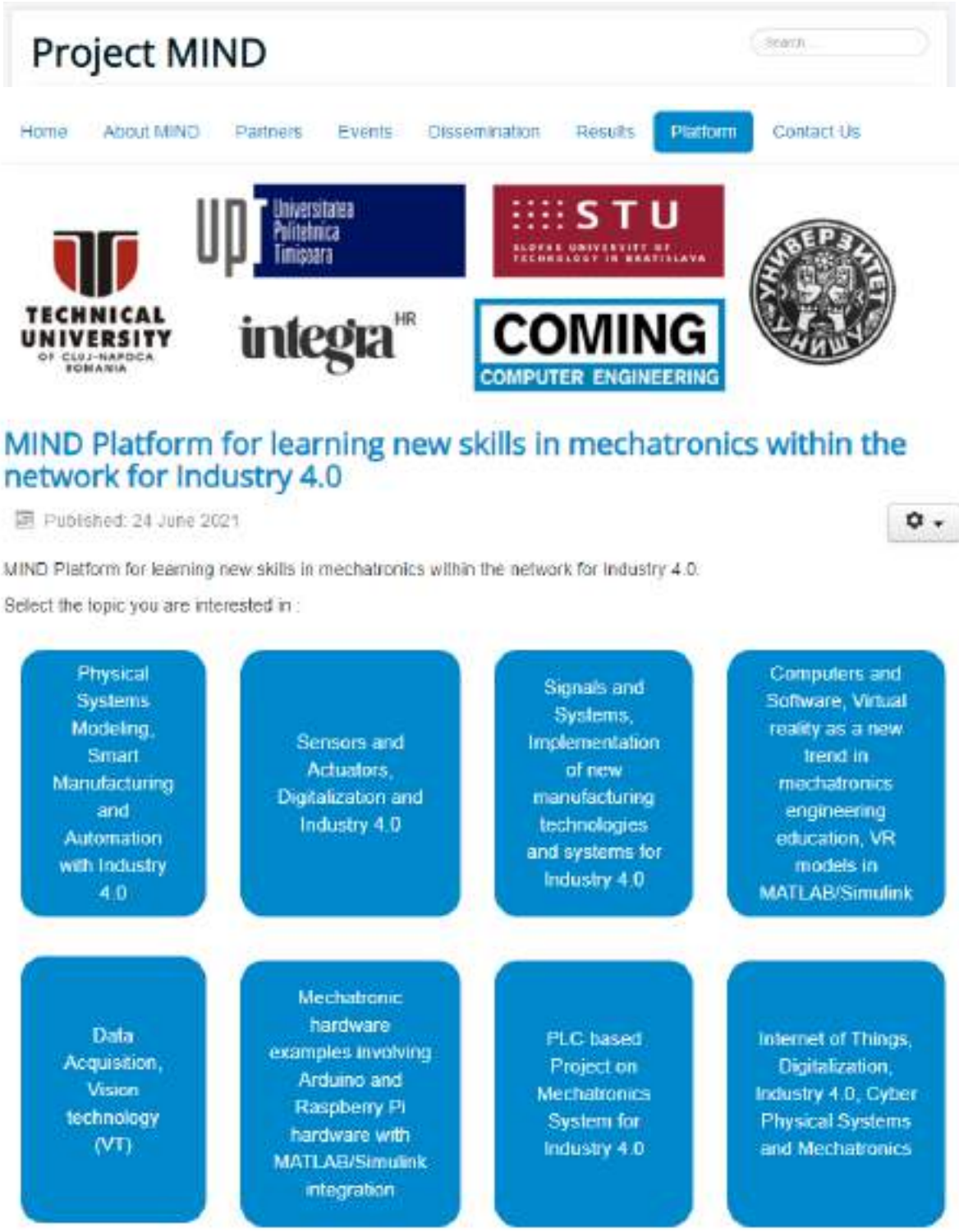

Fig. 3 MIND Platform

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As it was mentioned, the written part of the course was embedded in the platform, so that anyone can access it and read it directly on site. Also, this embedded solution provides the possibility to download the course and follow it later on the device without an internet connection.

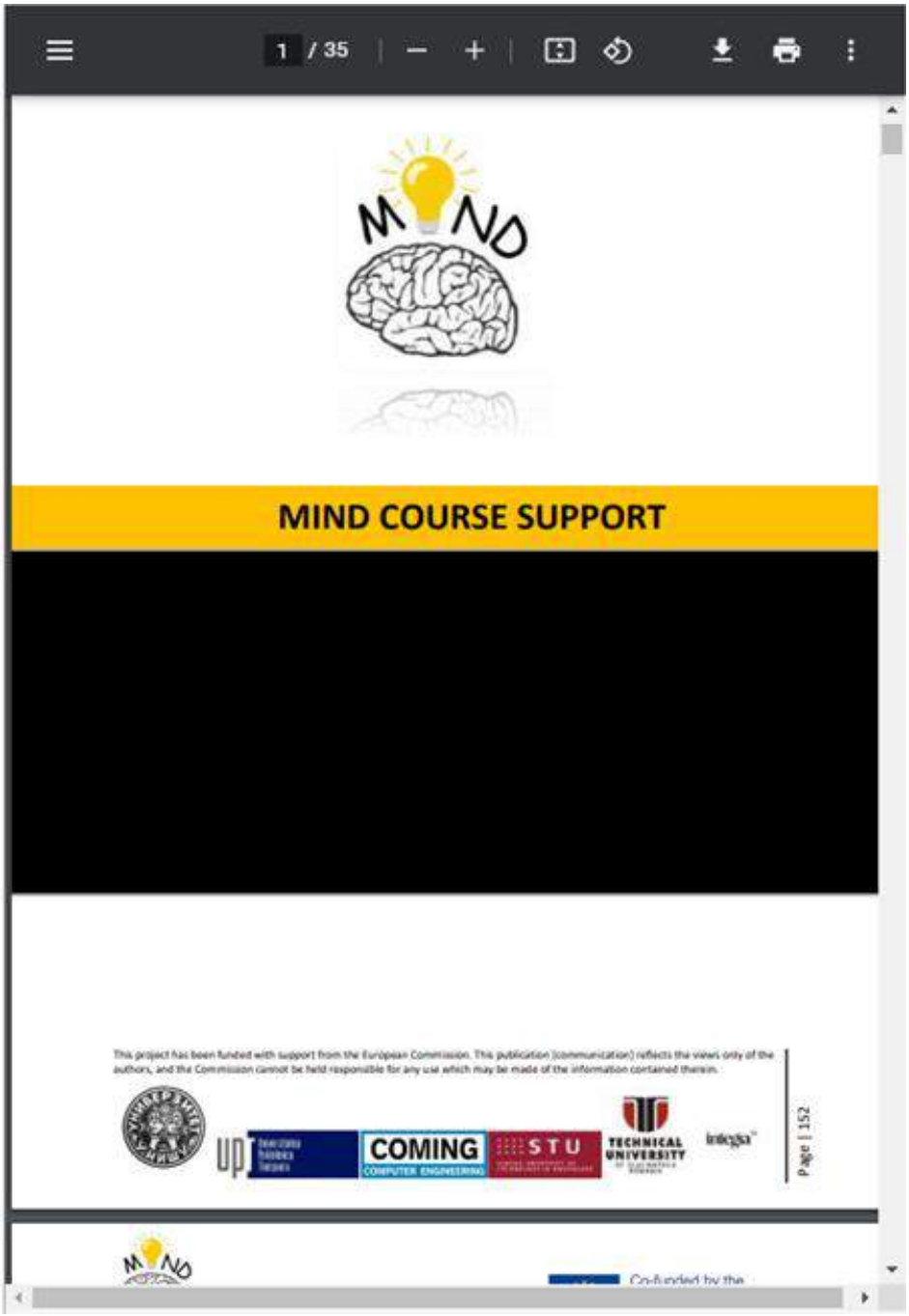

Fig. 4 Embedded written lecture

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The applicative part of the course is presented using videos. After reading the theoretical aspect of the module in the written course, students have the possibility to see a real-life integration of the information's that were presented before. Each video contains a footage of a real equipment used in industry. Also, there are videos that present some project that can be easily reproduce by the students, because they have theoretical background form the written course and the projects use hobby electronics components that can be easily found.

Like the course part, videos were embedded on the platform, so the students can watch them without switching to a different YouTube tab.

Fig. 5 Embedded videos

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Each module ends with an evaluation of the acquired knowledge using a questionnaire, which was built using Google Forms. If the student doesn't want to register on the platform, he can fill the questionnaire only by entering his email, in order to receive the results. The students have the possibility to answer once again to the questions that they answered wrong after the review the materials of the module. The questionnaire is embedded on the page, so all the materials can be easily accessed on one page.

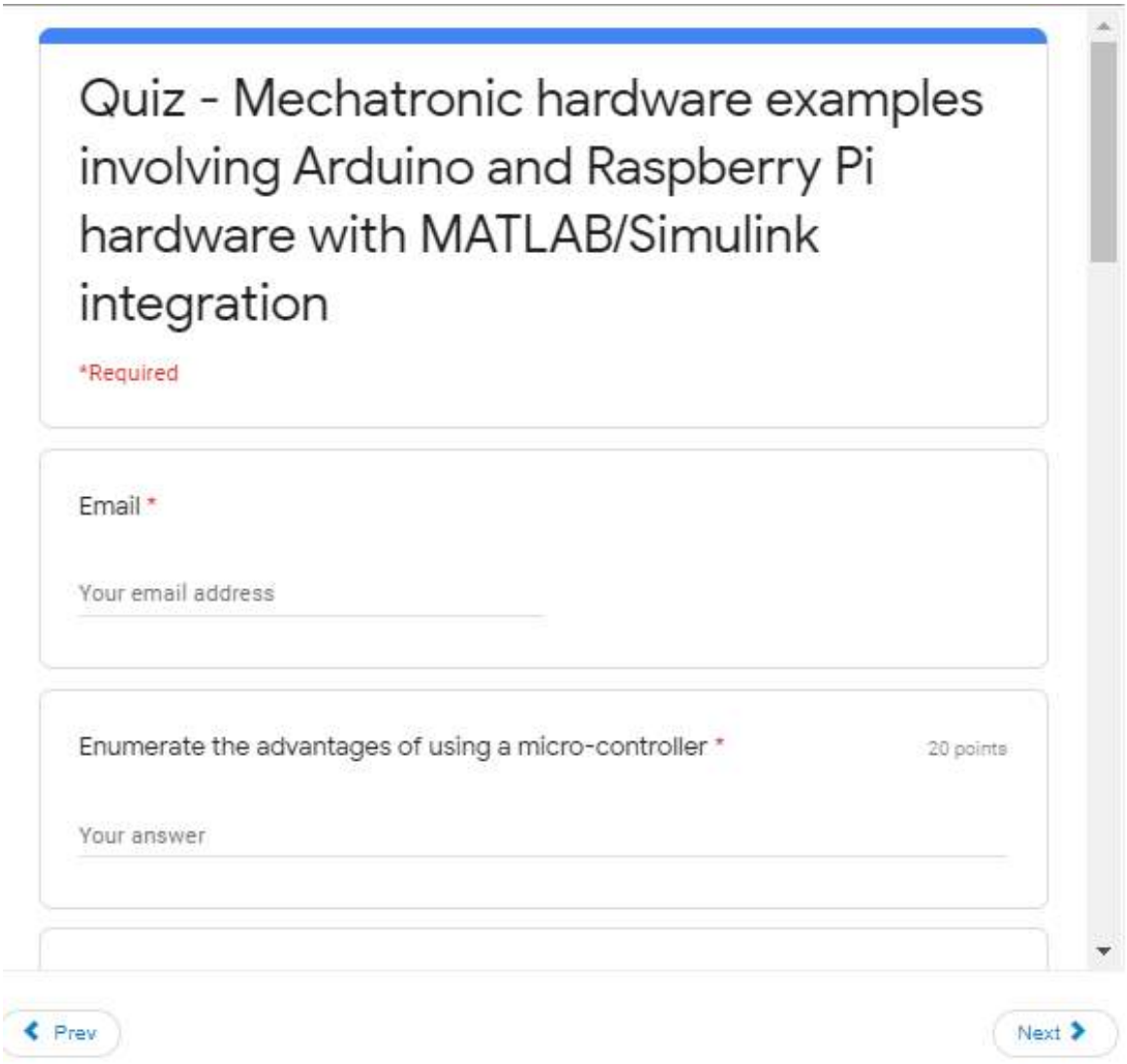

Fig. 6 Embedded questionnaire

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Each questionnaire consists of six multiple choice answers and two open questions, were the students need to describe an existing solution or to propose a solution for further enhancing didactic materials.

Each module will be covered in the following subchapters of the report.

3.1 Physical Systems Modeling, Smart Manufacturing and Automation with Industry 4.0

This course is designed to help students acquire both general and particular abilities as part of the MIND project consortium. This course is separated into two sorts of approaches, one with theoretical and one with practical goals. The theoretical goals are to produce as well as to improve knowledge of smart manufacturing as a modern manufacturing method. The topics discussed in this lecture are applicable to a variety of disciplines of study, including mechatronics engineering.

The practical components of smart manufacturing illustrate the basic principles of smart manufacturing using carefully prepared fictional examples as well as real-life, factory-proven examples. Alongside are some components advocated by important players involved in the industry 4.0 advancement [VAI18].

General objectives:

- Conceptualization of the concepts of smart manufacturing and automation
- Brainstorming on the benefits of implementing Industry 4.0,
- Comprehending the rather difficult subjects of smart manufacturing and automation in the context of Industry 4.0.

Specific objectives:

- Be familiar with the major Industry 4.0 paradigms with which they interact.
- Be familiar with the procedures necessary to build smart manufacturing solutions.
- To grasp the ideas of smart manufacturing for manual operations.
- To understand how smart manufacturing contributes to energy efficiency.
- To discover potential production optimization possibilities.

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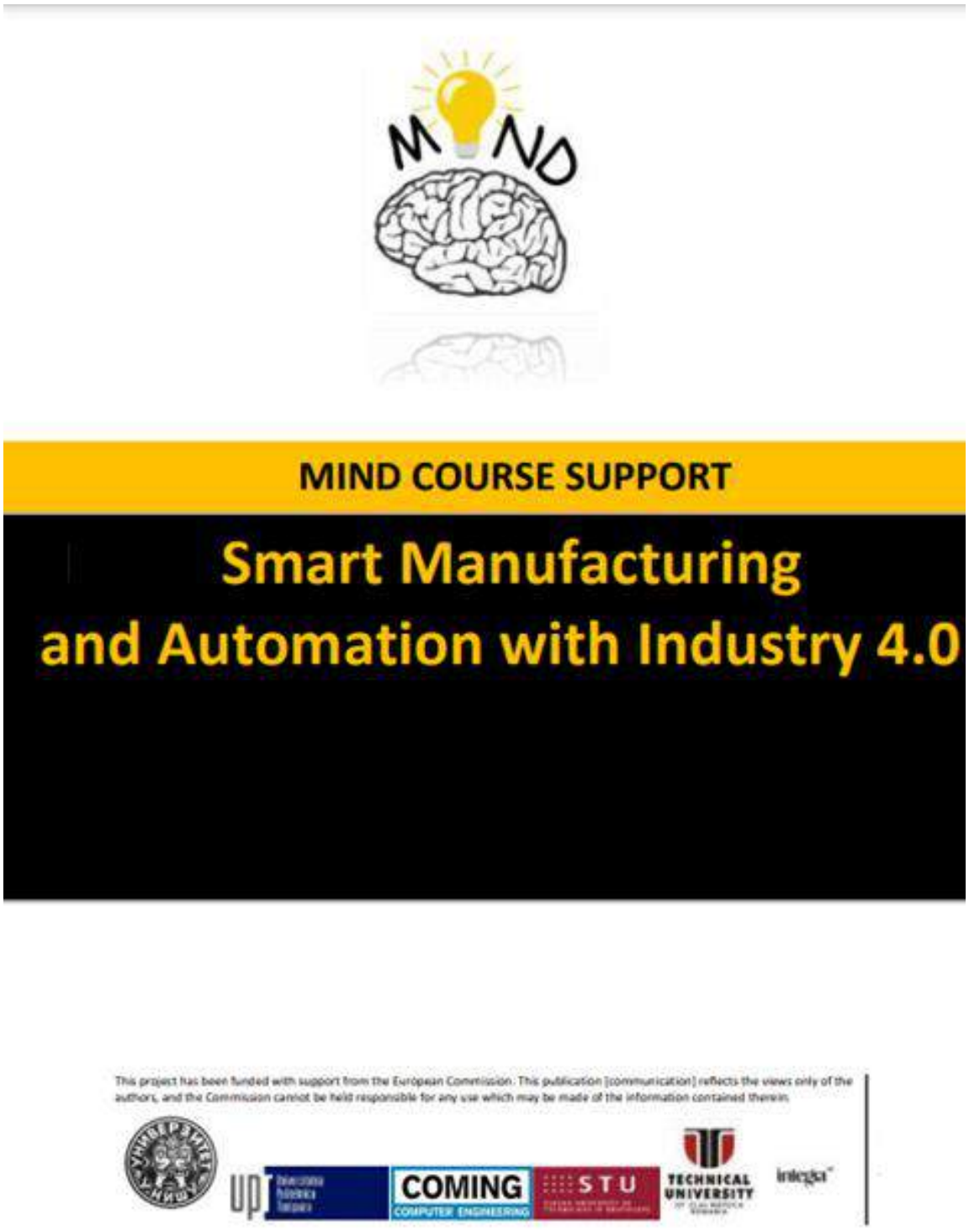

Fig. 7. Physical Systems Modeling, Smart Manufacturing and Automation with Industry 4.0 lecture

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3.2 Sensors and Actuators, Digitalization and Industry 4.0

The goal of this course is to gain understanding of data technology principles in order to enable digitalization of the industrial sector and Industry 4.0. Big data, cognitive analytics, and blockchain technologies will all be discussed in detail throughout the presentation. Every performed operation is noticed and registered by the huge amount of acquired data in today's digitalized world, especially in modern industrial contexts. Digitalized business systems with a constant intake of a significant quantity of data have been generated as a result of the adoption of the Industry 4.0 concept in manufacturing. This course will cover the idea of Big Data and Intelligent Analytics, which can effectively address that information, due to the importance of digitalization within Industry 4.0 and the strategies for gathering, storing, and processing that information. Finally, in the third part of this course, blockchain technology will be presented and the fundamental ways of working will be described in order to address the aspects of security and manipulation of gathered data utilizing the newest digital techniques [REI03].

The course's objectives are as follows:

- An introduction to Big Data concepts and characteristics.
- An understanding of different technologies for acquiring, analyzing, and processing data.
- An introduction to Blockchain technology.
- An understanding of fundamental Blockchain features such as security, decentralization, mining, hash functions, privacy, and authentication.
- Understanding the prerequisites for creating an optimum analytical environment.
- Introduction to descriptive, predictive, and prescriptive analytics- Demonstration of real-world Big Data, Blockchain, and Machine Learning-based Analytics applications .

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Fig. 8. Sensors and Actuators, Digitalization and Industry 4.0

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3.3 Signals and Systems, Implementation of new manufacturing technologies and systems for Industry 4.0

This course is designed to help students acquire both general and particular abilities as part of the MIND project consortium. This course is separated into two sorts of objectives: theoretical and practical. The theoretical goals are to produce as well as to better comprehend the notion of fast prototyping. These theoretical goals are concerned with the definition, identification, and application of advantages in many sectors of education, such as mechatronics engineering [PHI14].

3D printing has been highlighted as one of the most important innovations in industry since the beginning of the fourth industrial revolution (2010-2015). This means that future engineers will require new skills and expertise to meet the challenges of the fourth industrial revolution. Theoretical elements focus on leveraging rapid prototyping, which is based on innovative manufacturing technologies and systems, to improve students' and instructors' learning experiences.

General goals:

- Forming thoughts about the concept of fast prototyping.
- Forming ideas about the benefits of new manufacturing technologies and systems.
- Using fast prototyping to understand the rather complicated concepts of learning and prototyping.

Specific goals include:

- Knowledge of and understanding of the key 3D printing technologies.
- Knowledge of the processes necessary for quick prototyping.
- Knowledge of the steps required for rapid prototyping.
- To create a CAD model for 3D printing using a certain technique.
- To understand how it works.
- To pinpoint the source of a potential problem.

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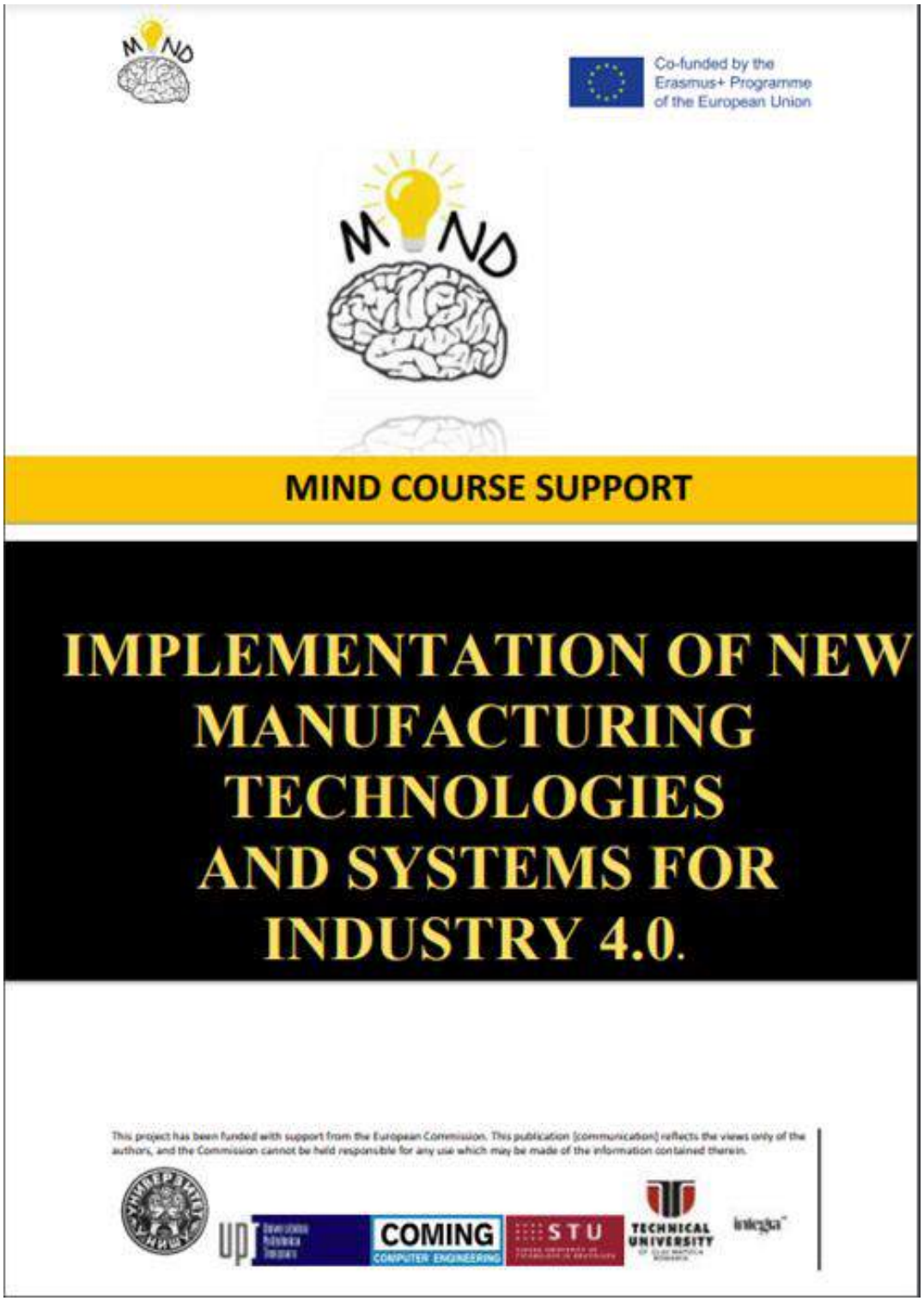

Fig. 9. Signals and Systems, Implementation of new manufacturing technologies and systems for Industry 4.0

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3.4 Computers and Software, Virtual reality as a new trend in mechatronics engineering education, VR models in MATLAB/Simulink

This course is designed to help students acquire both general and particular abilities as part of the MIND project consortium. This course is separated into two sorts of objectives: theoretical and practical. The theoretical goals are to produce as well as to improve comprehension of the notion of virtual reality as a new method of learning and teaching. These theoretical goals are concerned with the definition, identification, and application of advantages in many sectors of education, such as mechatronics engineering.

Theoretical elements are concerned with increasing students' and instructors' learning experiences by developing virtual models utilizing various software platforms such as MATLAB / Simulink, Unity, in which students may practice and design various actions or models [NEG16].

The following are the broad objectives:

- Forming concepts about virtual reality.
- Forming ideas about the benefits of interactive learning techniques.
- Using virtual reality to comprehend some of the more difficult aspects of learning.

Specific goals:

- To be familiar with the major devices with which they interact.
- To be familiar with the processes necessary to create virtual models.
- To construct virtual reality models.
- To understand how it works.
- To determine the origins of a potential problem.

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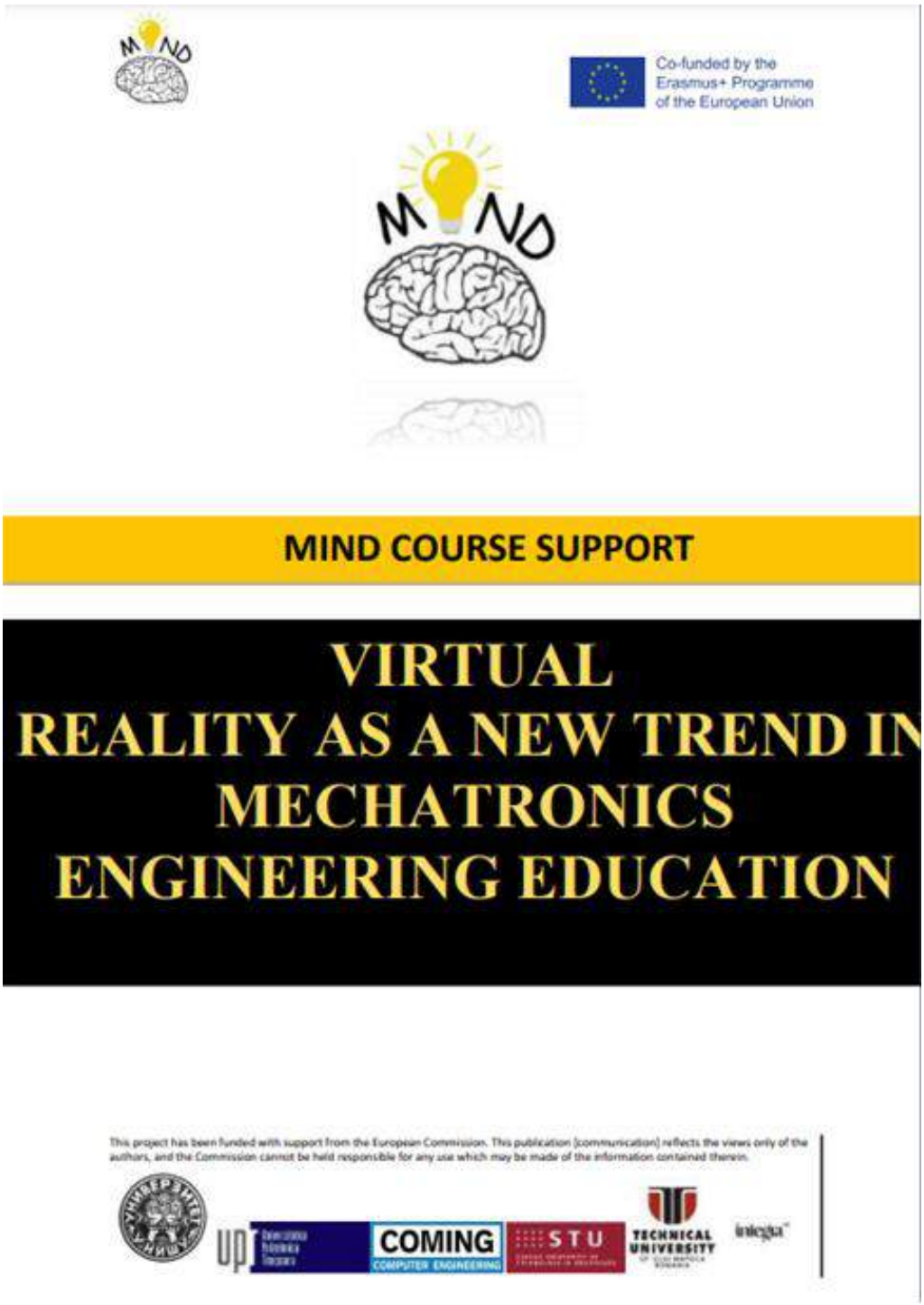

Fig. 10. Computers and Software, Virtual reality as a new trend in mechatronics engineering education, VR models in MATLAB/SimulinkData Acquisition,

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3.5 Vision technology (VT)

This module is based on understanding of picture-related topics such as artificial vision and image processing, learning, and using image processing techniques, as well as creating custom apps. Using image processing, and its basic concepts and methodologies to develop solutions to common issues that are solved with computer vision.

Fig. 11. Vision technology (VT)

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Following techniques, and methods will be covered in this module: digital image representation formats, camera model, statistical analysis, filtering, quality enhancement, restoration, segmentation, and measurements.

Students will be able to select criteria and techniques for evaluating the quality, performance, and limitations of image processing after completing this course.

The final step of the module is represented by developing and implementing of professional projects for image processing

3.6 Mechatronic hardware examples involving Arduino and Raspberry Pi hardware with MATLAB/Simulink integration

This module is mostly based on videos that are showing real projects that were developed by MIND project team using Arduino and Raspberry Pi hardware. These projects can be reproduced by students, and they are encouraged to add new functionality to the systems as connection via Wi-Fi or Bluetooth, adding more sensors to gather information about the system and use this data for a better control of the working process.

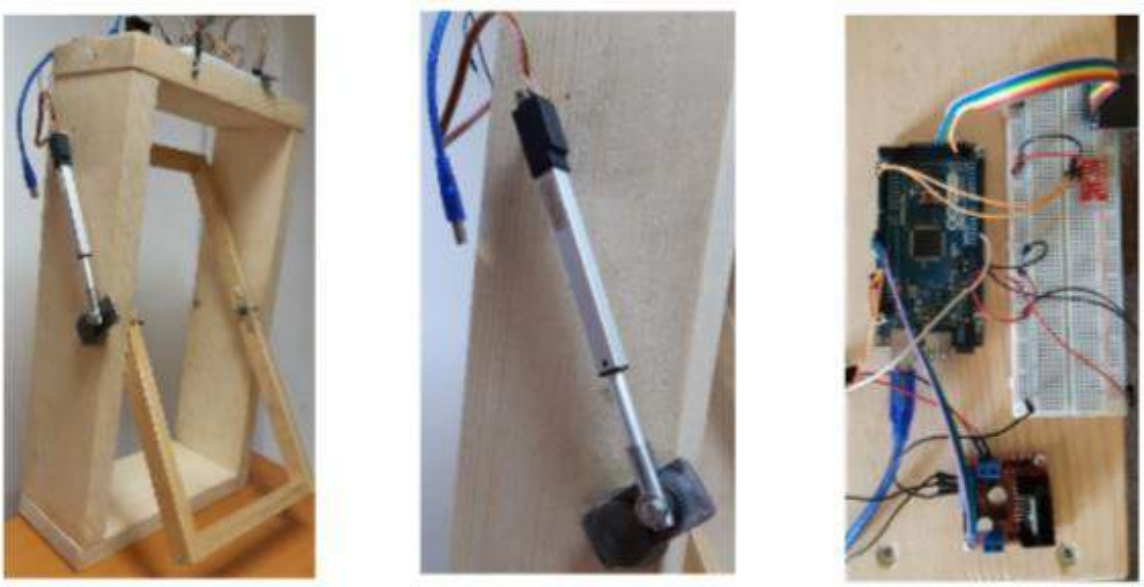

Fig. 12. Prototype of intelligent roof windows

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Fig. 13. Experimental prototype of the knee prosthesis

3.7 PLC based Project on Mechatronics System for Industry 4.0

This course has two types of objectives, theoretical objectives as well as practical objectives, that also will be covered by MIND videos. The theoretical goals address the difficulty of reinventing and reconfiguring PLCs (Programmable Logic Controllers) as the optimum alternative for industrial automation in order to meet Industry 4.0 needs. PLC-based projects on mechatronics systems for Industry 4.0 receive special attention.

These theoretical goals are related to the creation of PLC structures that are innovative, as well as the comprehension of new roles that PLCs will play in the Industry 4.0 future. In addition, as a result of the theoretical portion of this course, a summary of all new benefits of reconfigured PLCs will be offered [Lan19].

Practical aspects concentrate on improving students' and teachers' practical skills by establishing PLC networking and communication on various levels using various hardware/software platforms and protocols, such as PROFINET, Siemens Simatic S7-1200/TIA Portal/Web Server, and MATLAB, in which students can practice and design various actions or models.

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Fig. 14. PLC based Project on Mechatronics System for Industry 4.0

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General objectives:

- Knowledge of PLCs as core of industrial automation.
- Principles of reinventing and reconfiguring PLCs as best option for industrial automation to fulfil requirements of Industry 4.0.
- Knowledge of communication between PLC and other devices in term of Industry 4.0.
- Knowledge of using PLCs of different PLCs' producers.

3.8 Internet of Things, Digitalization, Industry 4.0, Cyber Physical Systems and Mechatronics

The global community of users has not agreed on a single definition for the Internet of Things. However, many different groups of researchers, innovators, developers, and academicians have defined the term as "an open and comprehensive network of intelligent objects that have the capacity to self-organize, share information, data, and resources, and react and act in response to situations and changes in the environment."

Only theoretical objectives are covered by the written course, the practical objectives are reached by the MIND videos. The theoretical goals address the difficulty of comprehending the ideas of the Internet of Things (IoT) as a basic technology for Industry 4.0 and putting them into practice [Ben19].

General objectives:

- IoT definition, architecture and characteristics.
- Basic term and conditions.
- History of IoT.
- Present and estimated future of IoT.
- Projects based on IoT examples (smart city, ect.).
- IoT in industry.

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Fig. 15. Internet of Things, Digitalization, Industry 4.0, Cyber Physical Systems and Mechatronics

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4 Conclusion

The development of a mechatronics educational platform must take into account current industry standards as well as future trends, such as industry 4.0; it must be student-centered, with an emphasis on what students learn in a problem-based learning environment; and it must take into account an integrated approach, blurring the lines between different disciplines, as real-life scenarios are not solved by a single discipline.

It's also critical that students are taught how to address challenges that are more community-focused rather than didactic. Students must be able to choose their own subjects that are most relevant to their personal development and career choices.

These criteria were satisfied by dividing the leaning materials in eight main modules, and for each module the theoretical and practical part was covered by written course and videos. Also, a possibility of tracking the results of studies was implemented by filling the tests that are attached to the end of each module.

The platform will be updated after receiving feedback from the users that tried the platform and have suggestions how it can be upgraded.

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Literature

[WAN13] Wang, C.H., Shannon, D.M. and Ross, M.E., (2013). Students' characteristics, self-regulated learning, technology self-efficacy, and course outcomes in online learning. Distance Education, 34(3), pp.302-323.

[MCB09] McBrien, J.L., Cheng, R. and Jones, P., (2009). Virtual spaces: Employing a synchronous online classroom to facilitate student engagement in online learning. International review of research in open and distributed learning, 10(3).

[WEI13] Wei, S., (2013), December. The Design and Implementation of a Mobile Learning Platform Based on Android. In 2013 International Conference on Information Science and Cloud Computing Companion (pp. 345-350). IEEE.

[VAI18] Vaidya S., Ambad P., Bhosle S., Industry 4.0 – A Glimpse, ProcediaManufacturing, Volume 20 (2018), pp. 233–238, https://doi.org/10.1016/j.promfg.2018.02.034

[REI03] Reichlin L., Watson M. (2003), "Big Data: Dynamic factor models for macroeconomic measurement and forecasting", Advances in Economics and Econometrics, Theory and Applications, Eighth World Congres, pp 115-122.

[PHI14] Brey P., Virtual reality and computer simulation, Ethics and Emerging Technologies, Palgrave Macmillan, UK (2014), pp. 315-332.

[NEG16] http://web.ulbsibiu.ro/catalina.neghina/Resurse/carti/carte_Matlab.pdf MATLAB: un prim pas spre cercetare / Cătălina Neghină, Alina Sultana, Mihai Neghină. - Sibiu : Editura Universităţii "Lucian Blaga" din Sibiu, 2016, ISBN 978-606-12-1213-2, ultima accesare dec. 2018

[Lan19] Langmann R., Stiller M., The PLC as a Smart Service in Industry 4.0 Production Systems, Applied Science, 2019.

[Ben19] Andrea Benesova, Martin Hirman, Frantisek Steiner, Jiri Tupa, Requirements for Education 4.0 and Study Programs within Industry 4.0, Proceedings of the International Conference on Industrial Engineering and Operations Management Pilsen, Czech Republic, July 23-26, 2019

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