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MIND

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DEVELOPMENT OF MECHATRONICS SKILLS AND INNOVATIVE LEARNING METHODS FOR INDUSTRY 4.0

IO6 REPORT

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1. MIND IO6 objectives

The MIND Guidebook for SMEs and other providers is the final product comprising all the previous results during the MIND project.

The shifting industrial landscape stemming from Industry 4.0 has significant implications for mechatronics curriculum, its accreditation, and the supporting university education system as a whole.

In order to meet the challenges of Industry 4.0, stakeholder groups have to prepare themselves for a digital transformation. Universities need to think about how to adapt their curricula and explore the possibilities of more flexible, smarter, modular, and reconfigurable laboratory structures that support and reflect the fluid nature of Industry 4.0.

In that sense, this guidebook contains guidelines for SMEs from the mapping their own needs in mechatronics related to Industry 4.0 to providing specific mechatronics skills for their workers needed to fulfil new demands required by Industry 4.0.

The role of this material is to actualize managers with the concept of Industry 4.0 and the relevance of a new curricula and e-learning teaching methods in order to develop new skills and competences for students, to meet the companies' requirements. This might be considered as a new approach of collaboration between universities (professors & students) and business sector.

During the MIND project, training material in mechatronics (course, curricula) with focus for Industry 4.0 needs and the e-learning platform have been prepared. This guidebook gives short description of prepared MIND training material and e-learning platform in order to guide SMEs' managers for using it for education of themselves and their workers.

This guidebook gives an overview of MIND results comparing with SME needs, demands, advantages and opportunities that adoption on Industry 4.0 brings to SMEs.

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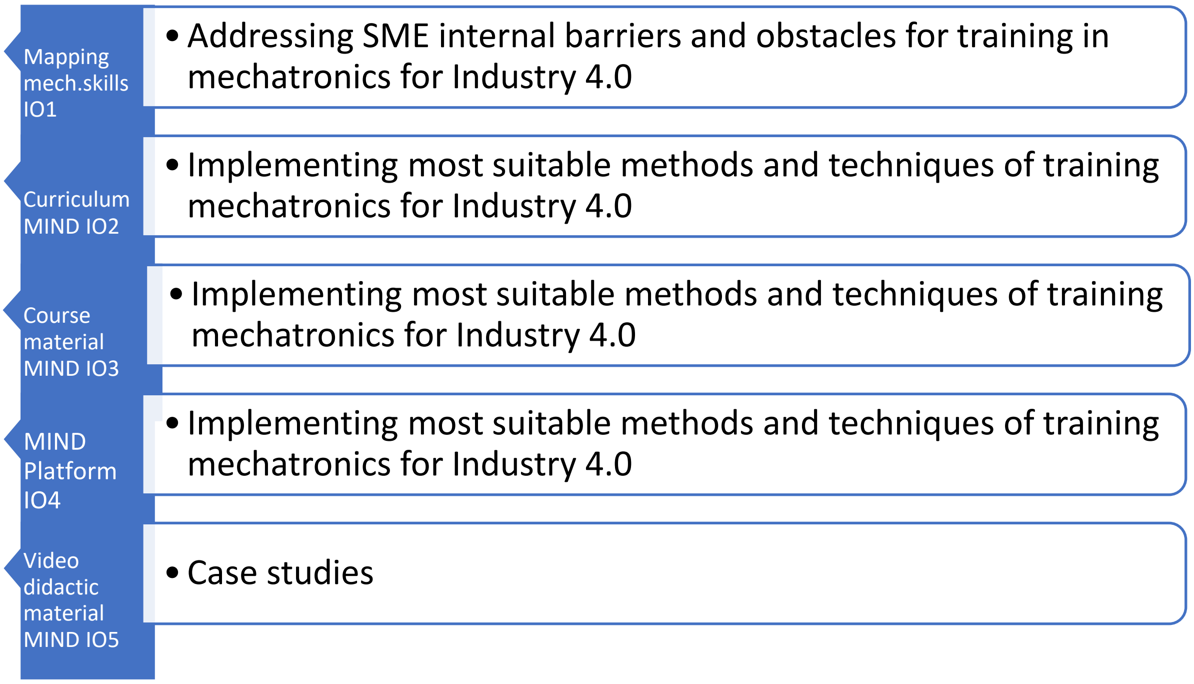

Figure 1. IO 6 overview of the MIND results

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2. Identification of SME needs, internal barriers, and obstacles for training mechatronics for Industry 4.0

The first issue to be clarified is the proper definition of SME needs related to development mechatronics skills for Industry 4.0. The second issue is awareness of SME managers and owners of internal barriers and obstacles in training mechatronics for Industry 4.0. On the other side, university sector should be ready to offer more flexible, interdisciplinary, and practical courses. All issues together have just one joint goal – to bring more skilled student to the market to fulfil SME demands and needs related to mechatronics for Industry 4.0.

The major challenge in mechatronics education is the lack of standardized curriculum, platforms, course material and other learning outcomes. In that sense, reaching consensus inside university sector and between university and business sector are very difficult and non-achievable goals at the moment. In addition, involving Industry 4.0 technologies in mechatronics education brings new challenges and barriers to reach standardized curriculum and learning methods.

Mechatronics education for Industry 4.0 should consider all new key elements of Industry 4.0 and to provide to students' sufficient knowledge to response adequately on SMEs demands.

On the other hand, a World Bank survey showed that a lack of digital and mechatronics skills within production companies is inhibiting "urgent needed" investments in Industry 4.0 technology. Industry 4.0 requires teams of people to work and hold interdisciplinary or multidisciplinary competencies to address emerging challenges. One of these requirements refers to the convergence between mechanical/electronic/software systems, and as a domain it is represented by mechatronics.

The MIND project is focused on developing mechatronics skills and innovative learning methods for Industry 4.0. To meet the employment needs of the next 5-10 years, universities must train students and develop interdisciplinary skills that combine mechatronic qualification with IT knowledge and superior social skills to create 4.0 specialists.

An important aspect of this review is the identification of the defining competencies of mechatronics in the context of industry 4.0 prior training. The skills in mechatronics are formed by a modern approach to the education process, characterized by the accumulation of competences.

The 'Flash Eurobarometer' survey on SMEs shows that 62% of EU SMEs confront barriers to digitalisation and 70% of EU SMEs say they are facing at least one obstacle that prevents their enterprise from becoming sustainable. In addition, the results validate the importance of the new SME strategy in contributing to economic recovery in Europe after the coronavirus pandemic.

According to this survey, one in five SMEs cite lack of skills among the barriers to engage in more sustainable practices, digitalise, and innovate. In that sense, to support SMEs to master the twin transition to sustainability and digitalisation and to grow, it is needed to make sure that they have access to the right skills and expertise.

The most mentioned barrier to digitalisation is uncertainty about future digital standards (24%). In terms of both sustainability and digitalisation a lack of financial resources is the next most cited barrier.

Mechatronics as a field covers a wide range of skills required for industry 4.0. Of course, improvements and additions to the skills required are needed. In order to identify the skills needed for Industry 4.0 in the partner countries of the MIND project, we have developed a form on the Google Forms platform that we have distributed to companies in the three partner countries (Serbia, Slovakia, Romania). This form was attended by 55 companies of large, small and medium size; the majority of these companies being producers, and a small part are in the field of development research and distributors. An important part of companies operates in the automotive field, the rest being in the field of mechanical, electronic engineering.

According to this survey and answers given from the SMEs, mechatronics skills are significant and extremely important for the development of their companies (Figure 2). Some companies say that mechatronics skills are not too important or not important, because these companies do not work directly with the production or mechatronics field.

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These companies are in the field's related services such as consulting, palletizing, industrial construction, finance services, etc.

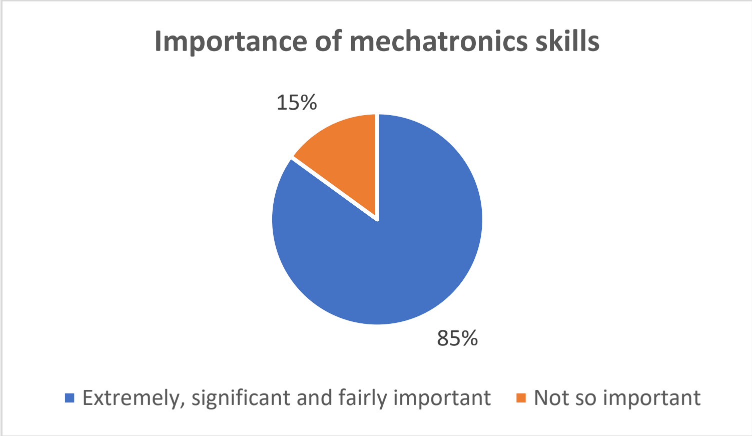

Figure 2. Importance of Mechatronics skills [MIND survey]

The question addressed to companies regarding how well trained their employees are in the field of mechatronics, most answered that they are trained in the 1-50% range. There is also a small part of companies that claim that their employees have a very high degree of mechatronics training (Figure 3).

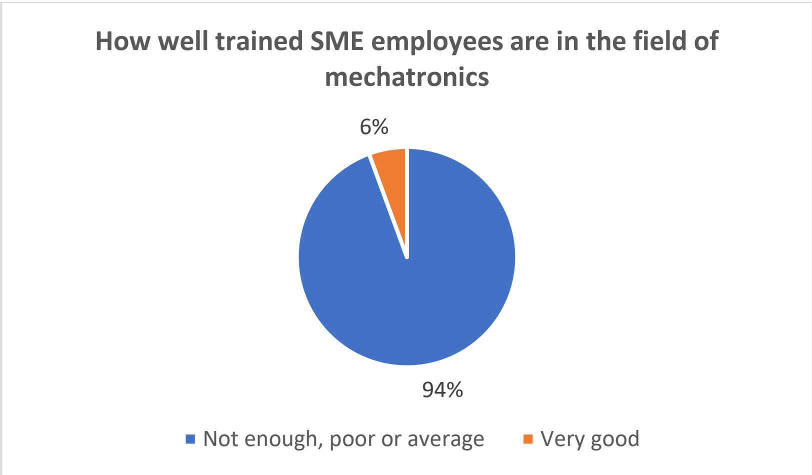

Figure 3. Training of employees in the field of mechatronics [MIND survey]

Most companies need a high level of mechatronics training, which is why most companies need a master's degree, followed by a bachelor's degree. A significant number of companies also need technicians who know the field of mechatronics at a lower level, but who have growth potential within the company in certain sectors (Figure 4).

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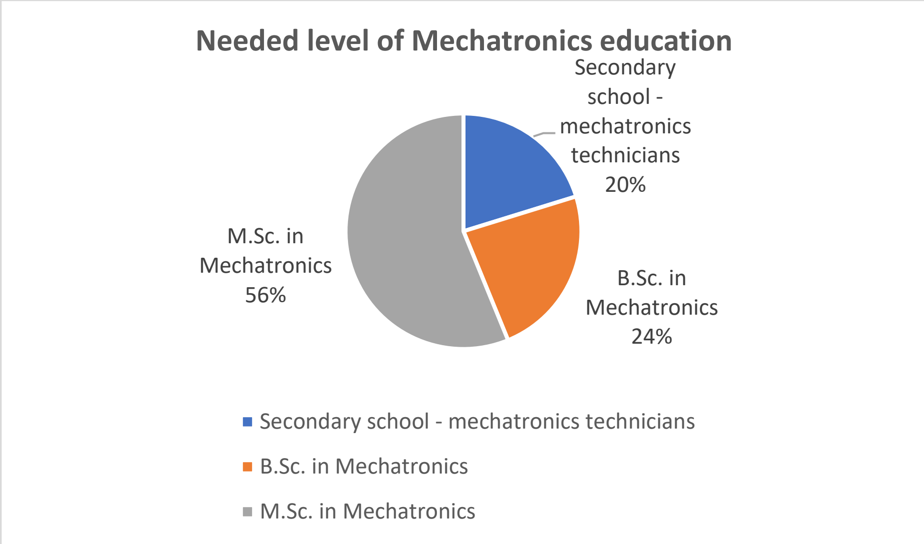

Figure 4. Level of education [MIND survey]

In the case of the competences that the specialized human resource must have to cope with the challenges of industry 4.0, the companies have chosen the competences of automation and those of the manufacturing technology. These two components are the majority in the preferences of the employers regarding the competences necessary to the individual in the industry 4.0. Another competency preferred by companies was IoT, due to the interconnectivity it offers between the common elements of the industrial process (Figure 5).

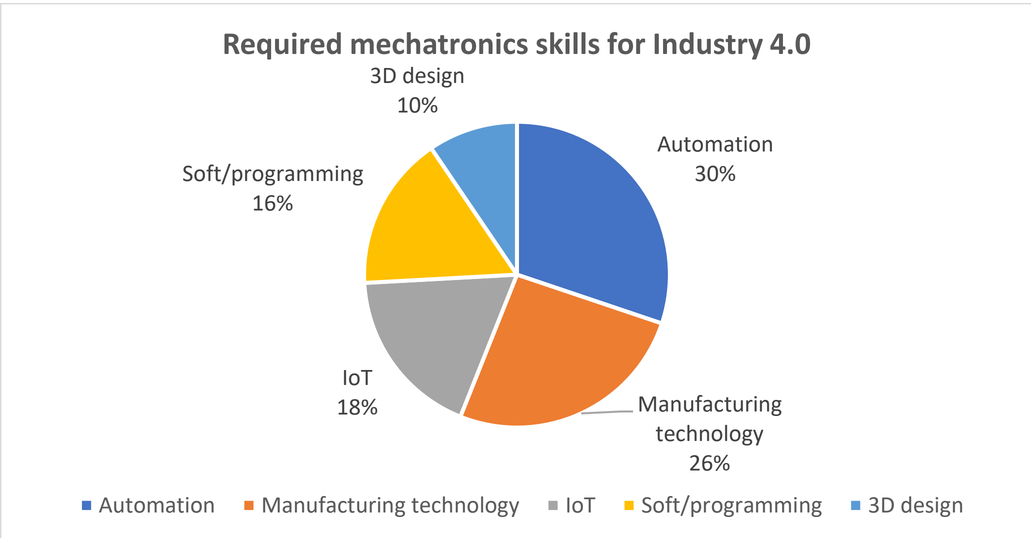

Figure 5. Required skills in industry 4.0 [MIND survey]

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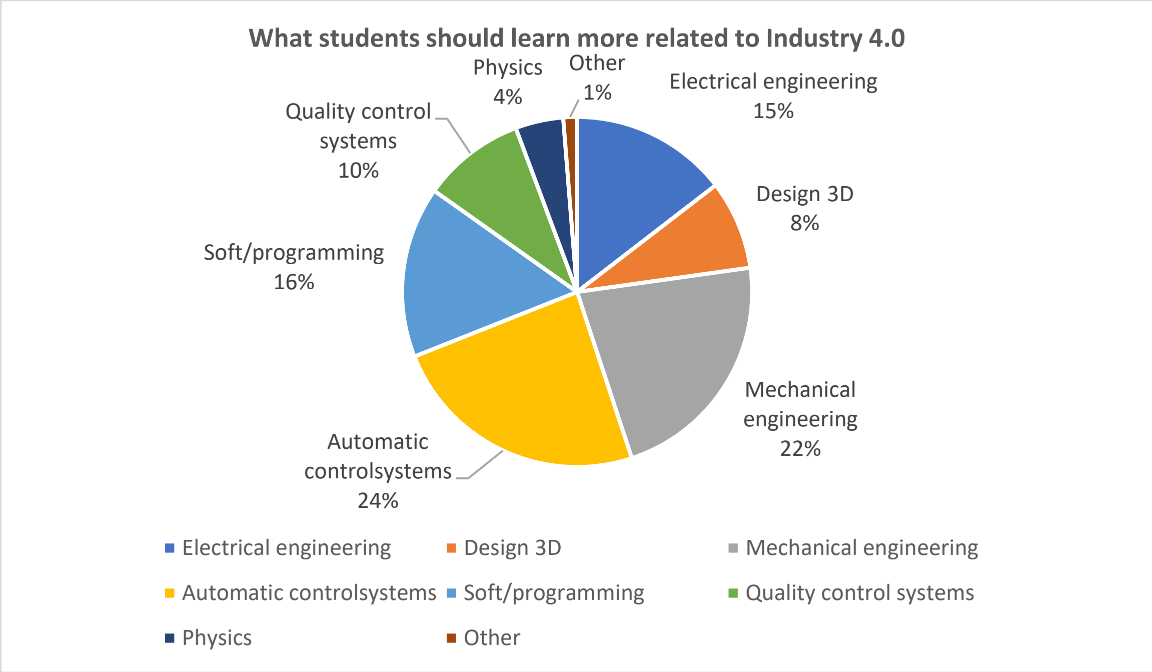

Figure 6. Important issues for students to treat seriously [MIND survey]

Internet of things and 3D printing / additive manufacturing are the preferred courses of most companies for master's students. SMEs believe that these courses would be useful to masters students, as they are a key element in reaching the 4.0 industry threshold (Figure 7).

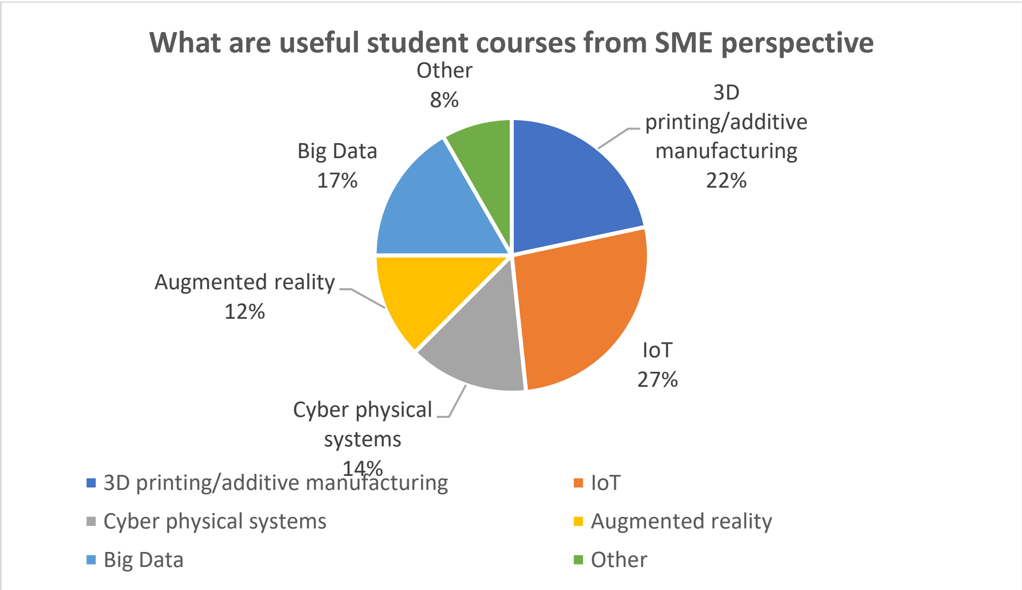

Figure 7. Useful courses for master students [MIND survey]

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The last question addressed to SMEs refers to the future vision of the company, most of them focused on the implementation of the principles of lean production, as well as equipping the company with autonomous robots or the Internet of things (Figure 8).

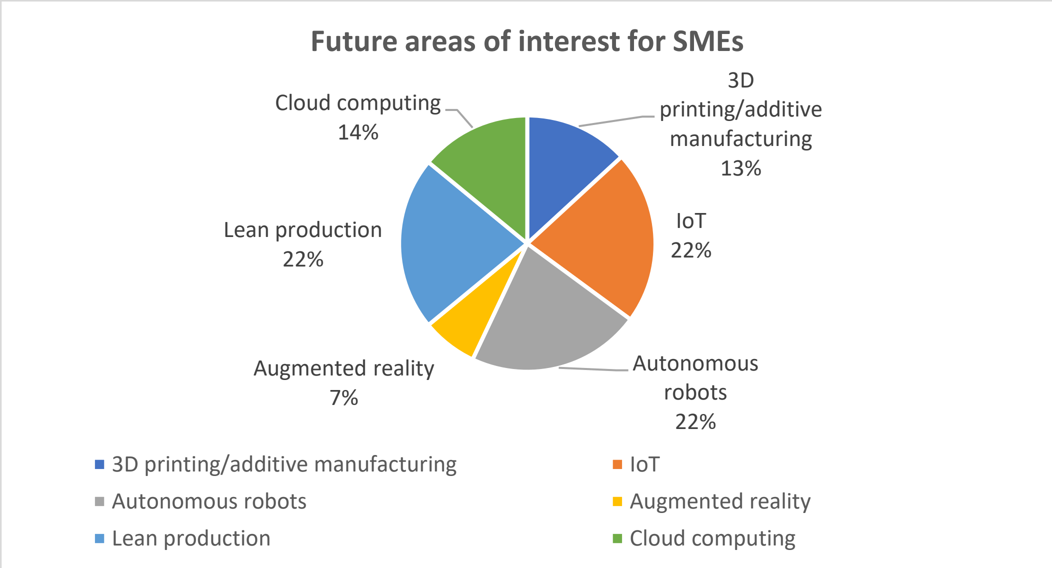

Figure 8. Future areas of interest for SMEs [MIND survey]

According to MIND survey results and other comparative studies, surveys and conclusions presented in IO1 report, each individual SME should consider its own needs and make collaboration with university sector in two-way direction: for selecting students with specific mechatronics knowledge after graduation in line with SME needs or to choose adequate mechatronics courses for additional education and development of missing mechatronics skills for SME employees.

In order to make this collaboration, clear, transparent and simple curriculum for mechatronics subjects and courses should be provided to SME managers and decision makers. In that sense, during MIND project, the structure of innovative, flexible and modern curriculum has been created and presented.

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3. MIND curriculum - choice of flexible structure for mechatronics courses

As it stated above, MIND curriculum should offer to SMEs quick overview how modern, innovative and time efficient is structure of subjects and courses realized by university sector. Regarding the fact that 4 universities from 3 different countries were involved in MIND project, this structure of curriculum has to be enough flexible to fulfil the minimal conditions related to each university individual rules and procedures. On the other side, providing such a flexible structure of curriculum opens potential for future cooperation in student exchanging for the field of Mechatronics in general.

There are four basic principles in the modern education system that should have in mind. These four principles are: student becomes the central subject of the whole system, the use of modern teaching means, modern means of teaching, learning, evaluation (learning based on project, peer to peer learning, problematization, etc...), developing critical thinking and problem solving. Changes in the educational system have occurred due to the evolution of society, and universities have had to adapt their methods to the demands of industry, economy, etc.

A substantial advantage of Industry 4.0 is that it offers a high level of flexibility. By flexibility we mean the ability of a system to be able to accommodate to different changes of the production flow, both from the perspective of changing the shape and dimensions of the product as well as the production process. The concept of flexibility is complex and quite difficult to define, analyze, or quantify. The high flexibility of a SME can be a decisive factor in comparison to other companies that do not have a high level of flexibility. The social and economic context forced the industrial environment to adapt to the new demands and challenges in order to face the economic market.

In that sense, courses, modules and subjects related to development of mechatronics skills has to be also enough flexible to follow permanent changes and new trends forced by Industry 4.0 and market in general.

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Development and improvement of technical skills and increasing competencies for Industry 4.0 become the most important challenging task and MIND primary objective is fully in line with.

Due to the fact that the industry branches are quite different, and the education system cannot cover all its fields, it is important that the employees are trained in the workplace or in the academic language of work-based learning (WBL). Of course, work-based learning is only an educational method by which individuals accumulate skills and are more specific in the industrial environment. On the other hand, in the educational environment, in the university there are modern methods of accumulation of competences that can be successfully applied in achieving the proposed objectives. Project based learning (PBL), peer-to-peer learning (P2PL) are just a few of the modern methods by which individuals accumulate skills that are so important in their integration into the social and industrial environment. This new approach to the education system is part of the modern education that is characterized by the positioning of the student as a subject of the educational process, the accumulation of competences, the development of critical thinking and problem solving as it is explained in MIND IO2 report.

The individual studying mechatronics, in the educational process, acquires a series of basic competences in the fields of 3D design, automation, software, advanced control of electromechanical systems, databases, unconventional process control, etc.

Developing a curriculum for mechatronics has to consider the current industry standards and the future trends in Industry 4.0; it has to be student centered, with the emphasis of what they learn in a problem-based learning; it is important to take into account an integrated approach, to blur the lines between different disciplines, as real-life scenarios are not solved by using only one field. Also, it is important that students are taught to solve problems that are related more to the community needs and less didactic centered. The curriculum must allow the students to choose their own subject that are most relevant to their personal growth and career choosing. Ideally, an apprenticeship-based curriculum might enable the previously stated points.

During the realization of MIND project, the proposed syllabuses covers the main aspects of industry 4.0: PLC based projects that enable understanding of automatization technologies, computer vision technology which paves the future for fully autonomous artificial intelligence agents, the internet of things which allows ad hoc networking between smart equipment, virtual reality that empowers the individual to innovate and learn in a new way, smart manufacturing and implementation of new manufacturing technologies which provide the tools for developing of smart eco-aware products, and digitalization, all these thematic constitutes a solid ground for teaching the main aspects of industry 4.0.

The following criteria have been considered and detailed explained in MIND IO2 report:

- Increasing needs on flexibility,
- University-Industry cooperation,
- Opening the learning systems,
- Shift in communication processes.

Occupation standards in mechatronics are standardized according to the European standards. “Qualifications are the formal outcome of an assessment and validation process which is obtained when a competent body determines that an individual has achieved learning outcomes to given standards” https://ec.europa.eu/esco/portal/qualification and https://ec.europa.eu/esco/portal/occupation?resetLanguage=true&newLanguage=en.

mechatronics

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Description

Mechatronics engineers design and develop intelligent systems, such as robotic devices, smart home appliances, and aeroplanes, through combining technologies from mechanical, electronic, computer, and control engineering. They create blueprints or design documents for parts,

Alternative label

mechanical systems

engineer mechatronic

engineering specialist

engineer in mechatronics

robotics engineer

electromechanical

engineer of mechatronics
mechatronics systems designer

specialist mechatronic engineer

advanced mechatronics engineer

2.4

Regulator

To see if and how this occupation is regulated in EU Member

In line with above mentioned analysis and criteria, universities need to think about how to adapt their curricula and explore the possibilities of more flexible, smarter, modular, and reconfigurable laboratory structures that support and reflect the fluid nature of Industry 4.0.

Here just the description of one MIND selected courses has been given below. It is syllabus for MIND Lecture 6 – "Implementation of new manufacturing technologies and systems for Industry 4.0" . Syllabuses for all developed MIND modules can be found in MIND IO2 report.

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1. Information about the specialization

1.1 University	Politehnica University of Timisoara
1.2 Faculty	Mechanical Engineering
1.3 Department	Mechatronics
1.4 Field of study	Mechatronics and Robotics
1.5 Degree level	Bachelor
1.6 Specialization	Mechatronics and Robotics

2. Information about the course

2.1 Course title	?				
2.2 Year of study	4	2.3 Semester	1	2.4 Evaluation method	Exam
2.5 Course type	Formative category				Yes
	Optionality				No

3. Time budget

3.1 Number of hour / week	2	divided in:	3.2 Lecture	2	3.3 Seminary	0	3.3 Laboratory	1	3.3 Project	1
3.4 Number of hour / semester	42	divided in:	3.5 Lecture	28	3.6 Seminary	0	3.6 Laboratory	14	3.6 Project	14

3.7 Time budget distribution (hours / semester) for individual activity:	
(a) Individual study (course, obligatory bibliography, etc.)	3
(b) Additional documentation (recommended bibliography, etc.)	2
(c) Preparation for seminary/laboratory/project activities	14
(d) Peer learning	2
(e) Exam preparation	6
(f) Other activities	1
3.8 Total individual study (sum (3.7(a)…3.7(f)))	28
3.9 Grand total (3.4+3.8)	70
3.10 ECTS credits	4

4. Preconditions

4.1 curriculum	Project MIND, lectures 1…5
4.2 competences	-

5. Course requirement

5.1. for lecture	Notebook
5.2. for seminary/ laboratory/ project	3D printer, PC, notebook, printer access, Internet access

6. Gained competences

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Professional competences	- Understanding of rapid prototyping – state of the art - Integration of rapid prototyping in smart manufacturing in an efficient way - Designing of parts according to selected 3D printing technology - Knowledge base enlargement regarding additive technology - Responsible professional tasks approach, in an autonomous way, without qualified assistance
Transversal competences	- Efficient management for conceiving, designing, planning and organizing specific activities. - Development of research projects, scientific studies or articles, BSc. Thesis. - Efficient use of IT, scientific and special resources, regarding the professional road - Applying efficient communication techniques within professional relation, with individual particularities.

7. Course objective

7.1 General objective	- Formation of notions related to the concept of rapid prototyping, - Formation of ideas on the advantages of new manufacturing technologies and systems, - Understanding the relatively complex topics about learning and prototyping with the help of rapid prototyping.
7.2 Specific objectives	-To know and understand main 3D printing technologies, -Knowledge of the steps required for rapid prototyping, -To prepare CAD model for specific 3D printing technology, -To know how it works, -To identify the causes of a possible problem.

8. Contents

8.1 Lecture	Hours	Teaching methods	Observation
Introduction in rapid prototyping	2	Presentation, demo videos, dialogue, examples	
Types of 3D printing	4		
Specifics of 3D printing – support structure, slicer	4		
FDM	4		
SLA	2		
SLS	2		
Other 3D printing technologies	2		
Examples of 3D printing in industry	4		
Bibliography As per references in Lecture 6			
8.2 Seminary / Laboratory / Project	**Hours**	**Teaching methods**	**Observation**
Project thematic selection	2	Dialogue, argumentation, documentation, 3D printing, pre	
State of the art exposal	2		
Proposed solution selection	2		
3D printing of selected projects	12		

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		and post processing of 3D printed parts, presentation	
Bibliography As per references in Lecture 6			

9. Evaluation

Activity	10.1 Evaluation criteria	10.2 Evaluation method	10.3 % of final grade
10.4 Lecture	Ability to express notions and make correct decisions, related to Rapid prototyping	Written Exam, 2h, 5 items, max. 9 points.	60% (max. grade=10)
10.5 Seminary/ Laboratory/ Project	Ability to carry out 3D printing	Content check, max. 6 points; Presentation 10 min., max. 3 points;	40% (max. grade=10)
10.6 Minimum performance:			5.0/10

There are three extremely important sections of syllabus from SME point of view. The first one is gained competencies. In this section, SME managers can see what professional and transversal competencies will be developed during the realization of this course. Nevertheless, SME managers can compare and analyze if these competencies meet previously defined SME needs and expectations from potential employees (students) or from existing employees through additional education.

The second important section is Course objective. Both types of objectives are very important. Reaching general objectives provides strong theoretical background and clear picture for solving complex problems. On the other hand, reaching specific objectives and meeting them with specific needs and plans of SMEs are extremely important in sense of selecting appropriate courses for students.

The third important section is Contents of course. It serves to SME managers to see in detail what is particular program of selected course and what teaching method will be used. In that sense, it is very significant to understand modern approach in learning methods that will be used for students of Mechatronics to meet SME needs and to be competitive on the market.

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4. MIND course support

MIND project gives course support material for 7 selected lectures that are of high importance for development specific mechatronics skills for Industry 4.0. This material primarily targetted teachers and students but finally content and accepted knowledge should be used for boosting SME flexibility and capability to deal with Industry 4.0.

The course support is minimum 160 and the number of training hours is minimum 18 hours. The difference from the existent one are the skills that can be gain in shorter terms to a variety of situations. These examples will be accompanied together with ongoing traditional mechatronics subjects like embedded programming, electrical or mechanical technologies.

By including all these aspects in the training program, this ensures a bottom-up approach when applying the concept of Industry 4.0 in businesses. The objective of achieving this course support is to develop critical thinking systems, to develop soft skills of team working, to learn affective by practical based approach.

The target group for this output are professors and the beneficiaries will be students willing to learn more about Mechatronics 4.0 but finally to provide an adequate feedback to SME needs and expectations. In the table below you can find the lectures that will be part of the course.

Lecture 1	• PLC based Project on Mechatronics System for Industry 4.0
Lecture 2	• Vision Technology
Lecture 3	• Internet of Things, Digitalization, Industry 4.0, Cyber Physical Systems and Mechatronics
Lecture 4	• Virtual reality as a new trend in mechatronics engineering education
Lecture 5	• Smart Manufacturing and Automation with Industry 4.0
Lecture 6	• Implementation of new manufacturing technologies and systems for Industry 4.0
Lecture 7	• Digitalization and Industry 4.0

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In order to help SMEs to realize what specific skill can be developed through appropriate lectures and to give practical preview of course support material for each of lectures specific table has been presented. In these tables, the basic SME needs that are covered by the lecture have been described as well as some illustrative examples.

PLC based Project on Mechatronics System for Industry 4.0	
SME needs to be fulfilled	Lack of competencies in managing smart factories, automation control of different processes in SMEs, need to provide adaptibility of manufacturing processes related to new control tasks, resolving communication issues related to PLCs in smart factory environment
General objectives	Knowledge of PLCs as core of industrial automation; Principles of reinventing and reconfiguring PLCs as best option for industrial automation to fulfill 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.
Specific objectives	Include the ability to analyze functional relationships in mechatronic systems; To provide fully integrated automation training, combining mechanics, pneumatics, electrical engineering, PLC control, and communication interfaces; To establish PLC communication using industrial network protocols and Internet; Knowledge of the steps required to provide communication of PLCs via TIA portal; Knowledge of establishing communication and connection of PLC with simulation software such as MATLAB
Practical learning examples • Prototypical implementation with Phoenix Contact controllers and the programming tool PC WORX	

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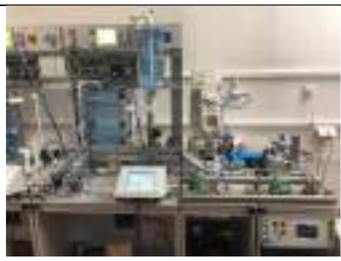
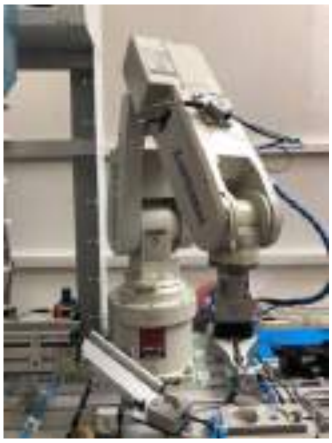
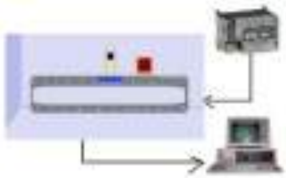
• FESTO Didactic learning stations PLC controlof different processes, remote monitoring, communication protocols... • 6 DOF Mitsubishi RV-2SDB and solving different controlling tasks combining robot and PLCs • establishing communication and connection of PLC with simulation software MATLAB and LabView – demonstartion examples • Industrial robot control FANUC LR Mate 200iD 4S – demonstration examples	   
SME application • machine control • industrial robot control • welding process control • different operations that involve storage, handling, and bagging • syrup refining that involves product storage tanks, pumping, filtration, clarification, evaporators, and all fluid distribution systems • Fats and oils processing that involves product storage tanks, pumping, filtration, clarification, evaporators, and	

all fluid distribution systems • dairy plant operations that involve all-process control from raw milk delivered to finished dairy products • oil and gas production and refining from the well pumps in the fields to finished product delivered to the customer • bakery applications from raw material to finished product • beer and wine processing, including the required quality control and documentation procedures	

Vision technology	
SME needs to be fulfilled	Lack of competencies in managing smart factories, lack of competencies in image processing and sensor fusion, innovation in visual inspection, obstacle and defect detection, new approaches in maintenance
General objectives	Understanding the concepts related to images, artificial vision and image processing. Learning and using image processing methods and designing specific applications.
Specific objectives	Knowledge, evaluation and use of concepts, algorithms and methods specific to image processing: digital image representation formats, camera model, statistical analysis, filtering, quality improvement / restoration, segmentation, measurements. of time and resources ▪ Development of capacities for qualitative and quantitative evaluation of results, algorithms and systems based on image processing ▪ Knowledge and use of specific programming / processing tools (MATLAB, OpenCV)

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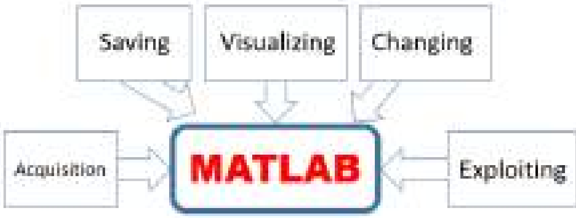
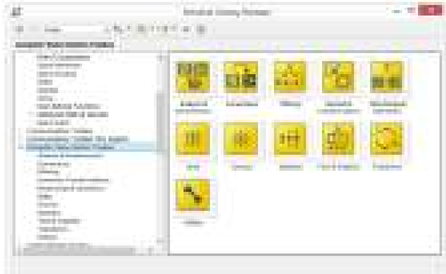
Practical learning examples • Implementation visual technology using MATLAB • Image processing in Simulink	 
SME application • on-board obstacle detection system for locomotives and autonomous trains • image processing based on AI • drones for obstacle detection and video monitroing • defect recognition in visual inspection tasks	   

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Internet of Things, Digitalization, Industry 4.0, Cyber Physical Systems and Mechatronics	
SME needs to be fulfilled	Lack of competencies in managing smart factories, lack of competencies in skills to manage M2M communications, RFID, IoT, IIoT... in smart factory environment
General objectives	Develop skills related to usage IoT and its parts in context of Industry 4.0
Specific objectives	Learn to implement some of the key elements of Industry 4.0: • specific Cyber physical systems • Internet of things • cybersecurity issues • to know the main equipment with which they interact, • Knowledge the steps required to make virtualization models, • to create a SCARA robot model and application, • to know how SCARA robot works, • to program and visualize a robot online.
Practical learning examples • Robotic system virtualization • simulation and online robot programming software	
SME application • virtalization of manufacturing	

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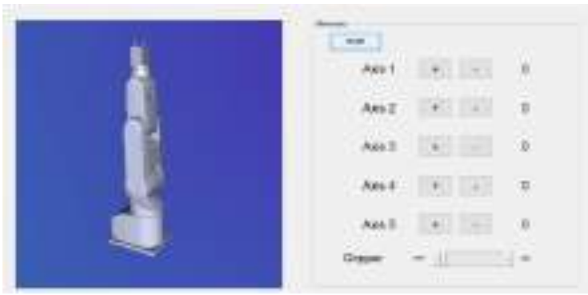
Virtual reality as a new trend in mechatronics engineering education	
SME needs to be fulfilled	New skills in preparation of the production and in design phases of the product visualization and distance monitoring of technological processes
General objectives	• Formation of notions related to the concept of virtual reality, • Formation of ideas on the advantages of interactive learning methods, • Understanding the relatively complex topics about learning with the help of virtual reality
Specific objectives	• To know the main devices with which they interact, • Knowledge of the steps required to make virtual models, • To create virtual reality models, • To know how it works, • To identify the causes of a possible malfunction
Practical learning examples • VR examples using MATLAB	
SME application • Virtualization of the robot • Maintenance / smart maintenance • Monitoring / condition based monitoring	 

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Smart Manufacturing and Automation with Industry 4.0	
SME needs to be fulfilled	Lack of new skills for smart manufacturing, need for develop skills for implement smart maintenance
General objectives	• Formation of notions related to the concept of smart manufacturing and automation, • Formation of ideas on the advantages of Industry 4.0 implementation, • Understanding the relatively complex topics about smart manufacturing and automation with Industry 4.0
Specific objectives	• To know the main Industry 4.0 paradigms with which they interact, • Knowledge of the steps required to develop smart manufacturing solutions, • To understand smart manufacturing concepts for manual processes, • To know how smart manufacturing helps energy efficiency, • To identify the opportunities for possible production optimization
Practical learning examples • Demonstration examples of simulation of smart environment	
SME application • Smart factory • Smart maintenance • Condition based monitoring	

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Co-funded by the Erasmus+ Programme of the European Union

Implementation of new manufacturing technologies and systems for Industry 4.0	
SME needs to be fulfilled	Lack of new skills for rapid prototyping, need for develop skills for implementing 3D printing methods
General objectives	• Formation of notions related to the concept of rapid prototyping, • Formation of ideas on the advantages of new manufacturing technologies and systems, • Understanding the relatively complex topics about learning and prototyping with the help of rapid prototyping
Specific objectives	• To know and understand main 3D printing technologies, • Knowledge of the steps required for rapid prototyping, • To prepare CAD model for specific 3D printing technology, • To know how it works, • To identify the causes of a possible problem
Practical learning examples • Using different CAD software for modelling and preparing for 3D printing • Using different 3D printing methods and different 3D printers • Demonstration examples using 3D scanners	  

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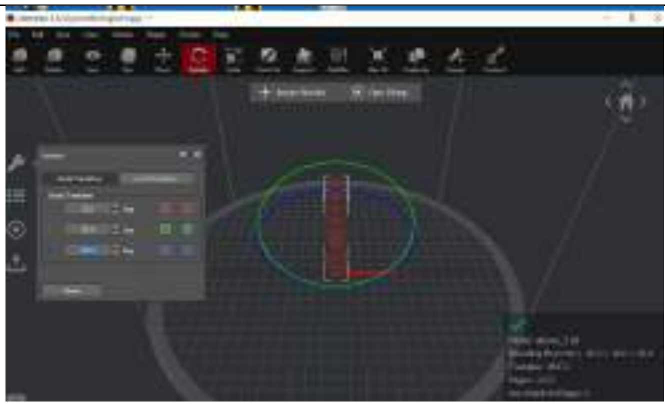
<tr><td></td><td></td></tr>
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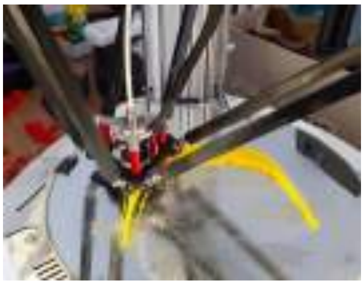
3D printed products
Rapid prototyping</td><td> 
 

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Digitalization and Industry 4.0	
SME needs to be fulfilled	Lack of new skills for handling and resolving complex issues for digital transformation of SMEs in line with Industry 4.0 demands
General objectives	• Introduction to the Big data concepts and characteristics • Understanding different technologies for acquiring, analyzing, and processing data • Introduction to the Blockchain technology • Understanding fundamental Blockchain features: security, decentralization, mining, hash functions, privacy and authentication • Gaining the knowledge of machine learning types commonly applied for analytics
Specific objectives	• Understanding the requirements for providing optimal analytical environment; Introduction to descriptive, predictive, and prescriptive analytics; Presentation of real-world applications in the domains of Big data, Blockchains and Machine learning powered analytics
Practical learning examples • Application of Big Data analytics using MATLAB and Python • Real-world ML applications and analytical approaches in Industry 4.0 using MATLAB and Python	
SME application Big Data application • Predictive maintenance, Predictive Quality • Defect/anomaly detection, Computer vision • Production Forecasting, Supply Chain Management, Work Cell Optimization • Product Lifecycle Management	

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5. MIND Platform and video didactic material as case studies for additional support for efficient development of mechatronics skills in Industry 4.0

The platform for e-learning is focused 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 was 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 can 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 can guide the students to the right path to learn mechatronics and the technologies used in Industry 4.0.

Regarding SMEs, MIND platform can be used from the side of SME managers for definition specific SME needs related to Mechatronics and cooperation with university sector in two-way direction.

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

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MIND platform covers the 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

Figure 9. MIND platform for learning new skills

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In order to provide efficiency of developing mechatronics skills for Industry 4.0, video didactic material is the counterpart of course support. The nature of mechatronics as multidisciplinary and complex discipline forced MIND teachers to extend teaching methods by systematic introducing video didactic material in teaching process.

In that sense, the main reason to use didactic videos to develop mechatronics skills is that the media will appeal to all students' senses and help them better process the information they receive. Video content helps teachers motivate students because it brings real life to the classroom, and a complete communication context represents the language. And instead of taking up more lessons (traditional care for the professor), they help save the teaching role.

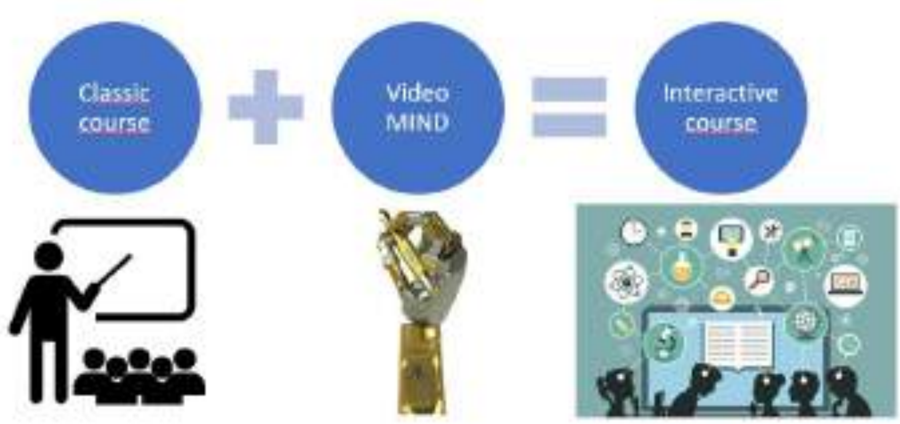

Figure 10. MIND concept of video didactic material

Videos cover modelling and simulation of mechatronic systems, sensors and actuators used in mechatronics, software and data acquisition from sensors and examples of mechatronic hardware include Arduino and Raspberry Pi hardware. All these videos are well explained in MIND IO5 report and available on the MIND website.

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6. Conclusion

The main idea of this Guidebook was to actualize managers with the concept of Industry 4.0 and the relevance of a new curricula and e-learning teaching methods proposed in MIND project in order to develop new skills and competences for students, to meet the companies' requirements.

This might be considered aa a new approach of collaboration between universities, (professors & students) and business sector.

A guide for SMEs containing a short description of training material in mechatronics (course, curricula) with focus for Industry 4.0 needs and the e-learning platform developed during the realization of MIND project.

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