EDUTRONIX

Interactive Education Module for Mechatronics

Project information

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The report presented here covers the period October 2015 - April 2016. It reflects the work shared with partners to date for the definition of the features of the interactive Edutronix module.

The final version will be made available and disseminated at the end of the project.

For the reader benefit, we anticipate the contents of the report.

In Chapter 1 you find a short description of Mechatronics, its application, trends and the future needs of mechatronics industry.

Chapter 2 presents the skills required by the latest technologies, the rapid development of mechatronics is conditioned by the continuous development and complexity of modern technologies and production.

Chapter 3 Focuses on the methodological approach that partners adopted to create the module

Chapter 4 the chapter identifies the main components characterizing the module and anticipates the methodological approach of module design

IINTRODUCTION

The **Edutronix project,** works toward the development and implementation of training methods to adjust the curricula in mechatronic within Technical Vocational High Scools to the changing needs of business, to improve the effectiveness of teaching and learning through practical and blended education, to create curricula linked to vocational tasks performed in the work environment.

Many companies see in mechatronic a structural driver of change. Despite of the market demands there is a lack of formally educated professionals in that area in most of the European Union countries. In the companies the jobs of mechatronic technician are often occupied by specialist with either mechanical or electrical professional education, which do not have the appropriate knowledge of mechatronics. The changes in this area of technology are so high, that normal vocational schools are often not able to follow them with respect to the contents and also with respect to the necessary technical equipment

The main goal is to create and implement an **interactive module for teaching and learning mecchatronics,** that should enable the development of the curricula in the field of Mecchatronics, delivered by Technical Vocational High schools, first in the project partner countries, then, through the dissemination and exploitation activities in other European educational settings.

This report is to present the work done to date by the project partners, for the definition of the methodological approach for the designing of EDUTRONIX interactive module; the process of development the interactive module can be summarized as follow:

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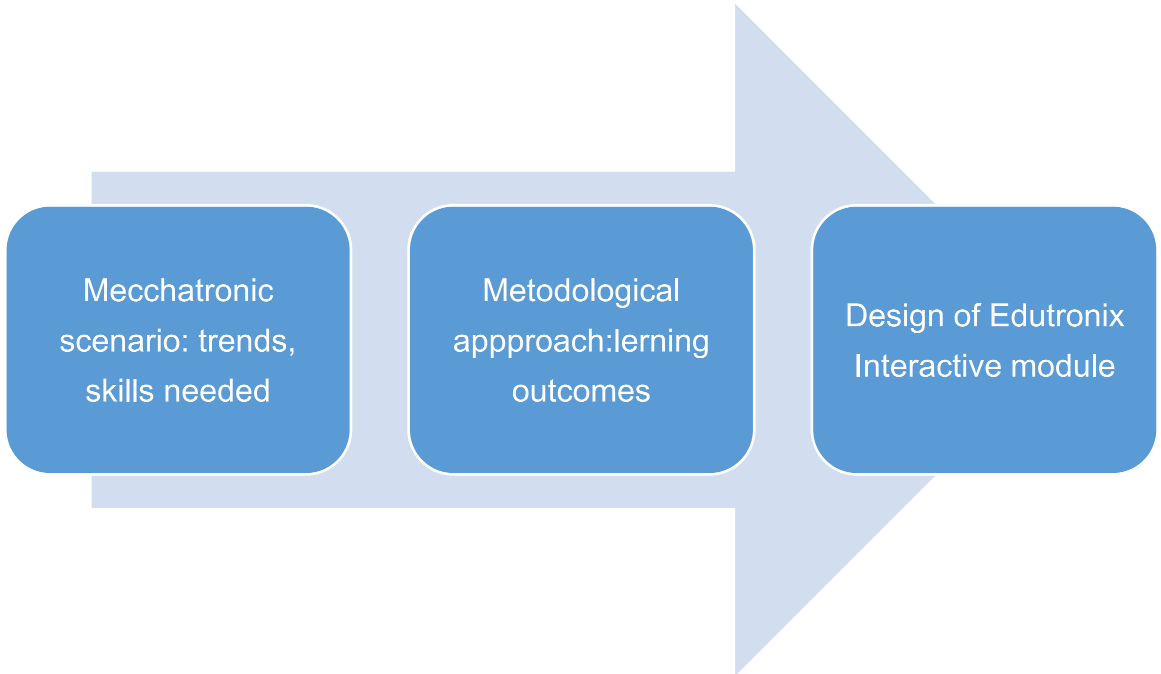
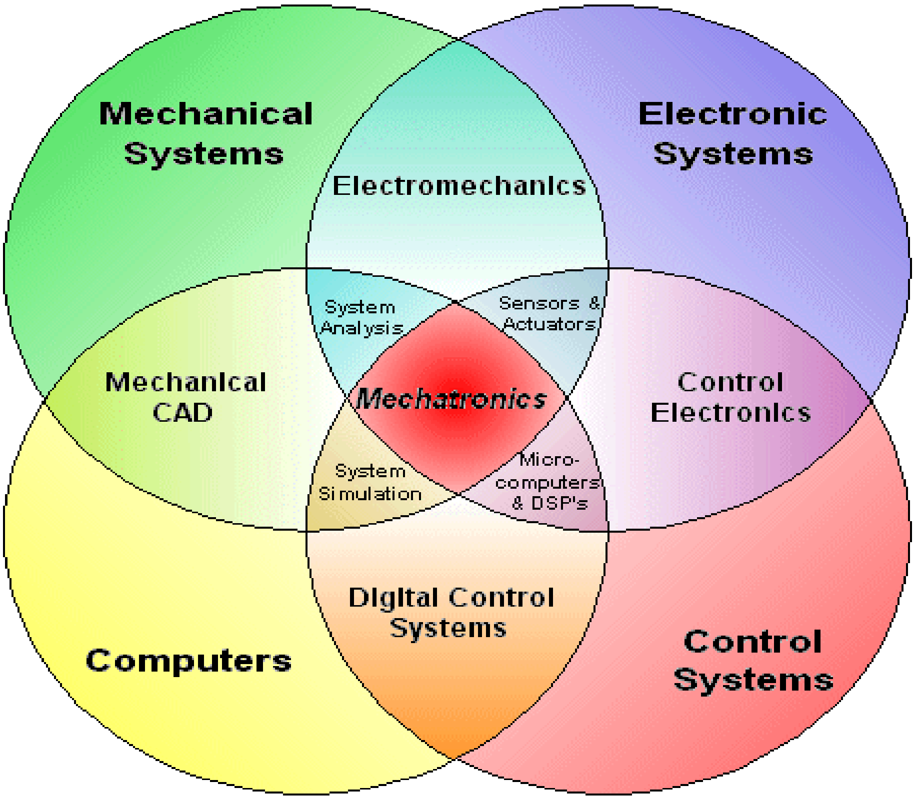


1. OVERWIEW OF MECHATRONICS

Mechatronics was first used in terms of the computer control of electric motors by an engineer at Japan's Yaskawa Electric Co. Many engineers contend that mechatronics grew out of robotics. Early robotic arms, then unable to coordinate their movements without sensory feedback, benefited greatly from advances in kinematics, dynamics, controls, sensor technology, and high-level programming. During the 1970s, mechatronics was concerned with servo technology used in products such as automatic door openers, vending machines and autofocus cameras. In the 1980s, as information technology was introduced, engineers began to embed microprocessors in mechanical systems to improve their performance. The 1990s saw the full arrival of the mechatronic age because of the increased use of computational intelligence in mechatronic products and systems.

Today the term "mechatronics" encompasses a broad range of technical disciplines including mechanics, electronics, control systems and computer systems. As a result of this breadth, the term has number of different meanings to different people. In this report,the term "mechatronics" is defined in the broadest sense. That is, mechatronics is defined as the multidisciplinary application of mechanics, electronics, control systems and computer systems to optimize the performance of products or processes.

Mechatronic is considered one of the structural drivers of change in industry.

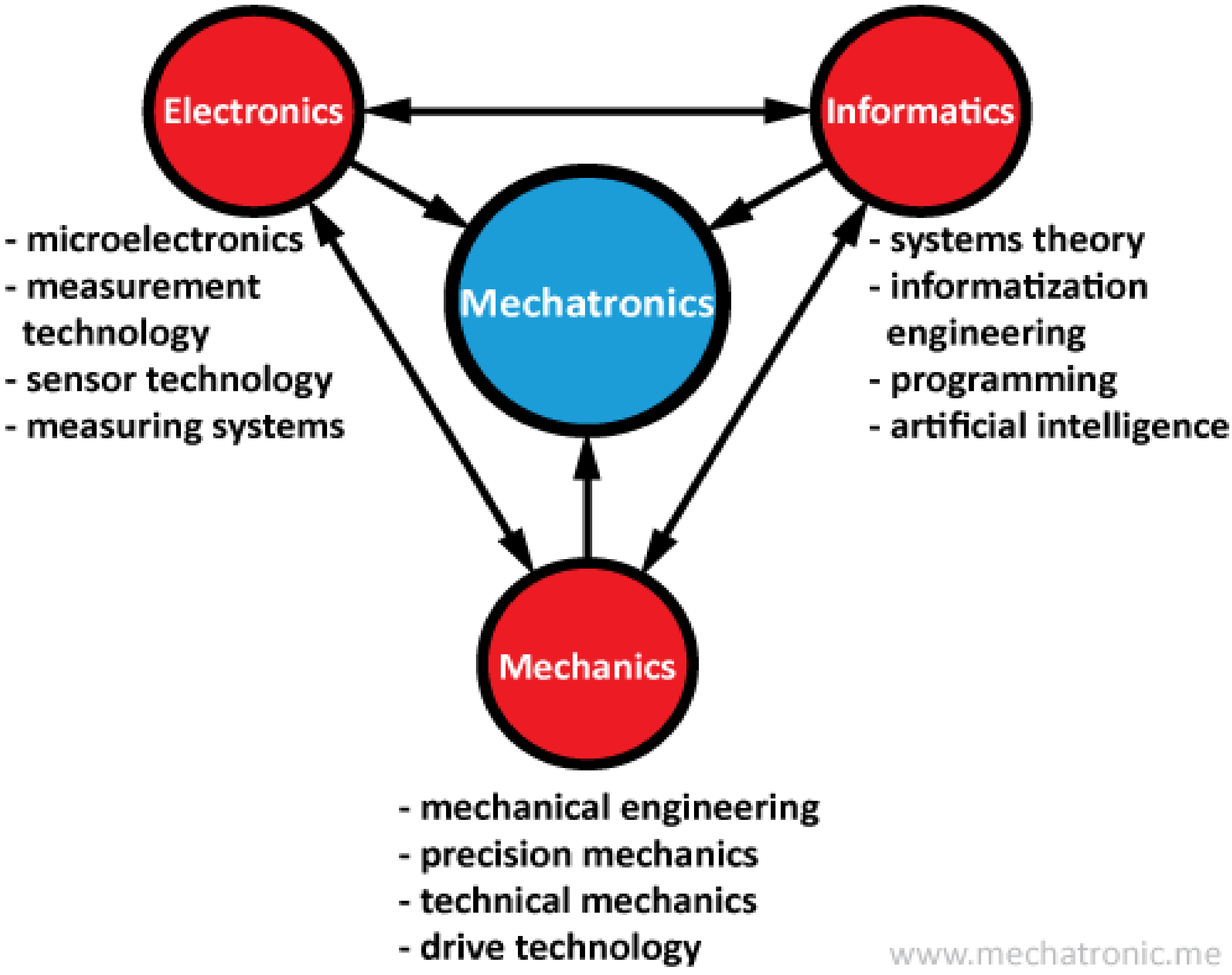


The aim of mechatronics is to improve the functionality of technical systems and the creation of new concepts of machinery and equipment with built-in 'artificial intelligence'.

In various literature sources **several definitions of mechatronics** can be found, almost all of them put the emphasis on the functional integration of mechanical actuators with electronics and computer control:

"Mechatronics is a synergistic combination of precision engineering, electronic control and mechanic systems. It is the science, that exists at the interface among the other five disciplines: mechanics, electronics, informatics, automation, robotics"

Isermann defines mechatronics as a *combination of knowledge from three disciplines - mechanics, electronics and computer science.*



Applications

There is no mechatronics industry sector; rather, it is an enabling approach to technology that is increasingly applied in a number of economic sector:

Biotechnology, Life Science and Medical Electronics and Applied Computer Equipment, telecommunication and Information Services,, Distribution, Transportation and Logistic, Heavy and Special Trade Costruction, Energy, Mining and related Support Services; Petroleum Refining and Chemical, Transportation Equipment, Production Support and industrial Machinery, Agricolture, Forestry and Food, Aereo Space, Homeland Security and Dedefense.

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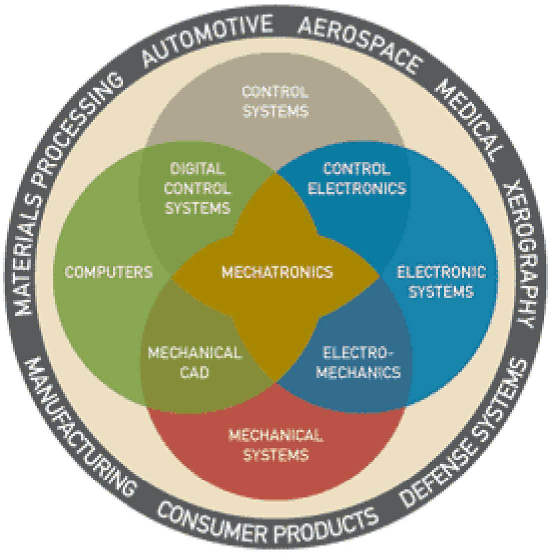
The application fields of Mechatronics can be illustrated as follows:



Examples of applications:

- Control Systems (position, level, pressure and heat control systems…)
- Robots (transport and welding robots)
- Industrial Automation (barcode systems and production belts)
- Building Automation (security systems, automatic air conditioning and automatic door systems)
- Home appliances (washing machines and dish washers)
- Automotive (air bag, antilock braking system)
- Defense Industry (mine detection robots, automatically guided vehicles)
- Medical Applications (magnetic resonance, arthroscopic devices, ultrasonic probes etc.)

- Aeronautical Engineering (automatic pilots, unmanned aerial vehicles)
- Image and Sound Processing (automatic focusing devices, sound-operated devices)
- Production (Computerized Numerical Control -CNC, Numerical Control -NC)
- Laser optical systems (barcode)
- Intelligent measuring devices (calibration devices, testing and measuring sensors.

The key trends on the European market for mechatronics

Globally, the mechatronics technological and research scenario has been changing compared to the recent past. Growth in demand, as well as growth in terms of products that feature in the mechatronics, can be expected well into next decade and beyond. Companies are increasingly looking to automation to accelerate production methods and reduce manpower.

The main driver of change is represented by highly complex technological designs and inter-interdisciplinary solutions which request a synergic integration of many aspects of the engineering knowledge base.
The trend of embedding devices with more intelligence (embededded electronics) into mechanical systems is likely to increase as the performance of processors, memory , storage and bandwith continue to increase while relative costs decrease. Additionally, standardized communication protocols and infrastrucutes, such as internet protocols, will continue to simplify interconnections and control devices through industrial networks.

The main drivers on the European market for mechatronics are **technological and economic.**
The on going **information technology innovation**, developments in wireless communication, smart sensor design and embedded systems engineering ensure that mechatronics design will continue to evolve throughout the next decade.
With reference to market, in the Eu region, the major automation system builders have expanded their range to enable the supply and integration of complete system. This the results of a growing number of customer require integrated packaged supply that includes design, product supply and commissioning from a single source

2. FUTURE TRENDS IN SKILLS DEMAND AND SUPPLY ACROSS THE EUROPEAN UNION

The Cedefop's 2016 skills forecast offers insights into future trends in skills demand and supply across the European Union

Trends are being driven mainly by demographic change,better access to education, technological advance and climate change. These drivers are expected to impact employment, occupations and qualifications in all sectors across the EU between now and 2025 in different ways; particularly by: increasing need for high qualifications,high replacement demand, changing jobs in contents and tasks

All sectors are expected to employ **more highly qualified people,** reacting to a combination of demand and supply factors. Technology, by replacing routine tasks, is making jobs more demanding and requiring higher skills Education attainment across the EU has risen, substantially increasing the pool of more highly qualified people available; when employment demand is low, some people will take jobs below their qualification level;

Despite the trend towards demand for high-level qualifications, around 47% of all jobs will require **medium-level qualifications**. Demographic trends mean that around 14 of every 15 job openings will be to replace workers leaving their jobs, many of whom will retire. In many cases, not enough young people will enter the labour market to replace those leaving;

Technological advance, through developments such as automation and the impact of the 'internet of things', sometimes termed the fourth industrial revolution, is expected to have major and lasting effects on job content and tasks. Automation, using robots and artificial intelligence, is already replacing routine tasks both in blue- and white-collar jobs at all qualification levels

Due to this, skills demand in mechatronics is on continuos move.

Technology induced new forms of collaboration and data collection are also changing work organization and production processes, including working times and locations.

To support the Eu workforce in 0preparing for the anticipated effects of these trends, education and training need to ensure:

- a balance mix of skills across sectors, countries and qualification levels,
- broader skill profiles across occupations and qualifications, combining technical and behavioural skills;
- acquisition of new specialised and technical skills as these are changi ing more rapidly
- throughout working life.

New skills in the latest technologies, advanced manufacturing

Advanced manufacturing is the use of cutting edge skills or technologies to generate efficiencies and improvements to production processes. These techniques include the use of advanced robotics and 3D printing. Advanced manufacturing increases competitiveness by improving the speed and quality of production, as well as supporting the EU to achieve its carbon reduction targets by reducing waste, pollution and energy consumption.

Although the manufacturing sector is expected to continue to decrease in size over the next decade, **advanced manufacturing is expected to grow significantly**, with the global market expected to double in size up to 2020.

This is driven by particularly strong growth in:

1 3-D printing, which expected to grow globally by 13.5% from 2012 to 2017; and

2 Robots and robot related products

The growth in advanced manufacturing is forecast to lead to an **increase in the number of high-skilled jobs in the sector**. Growth in Research and Development (R&D) investment will increase demand for engineering jobs at graduate and intermediate levels.

Advanced manufacturing techniques can be applied across all parts of the manufacturing sector. It is not, therefore, a discrete element of manufacturing. It is, however, more concentrated in particular industries. High-technology industries are defined to include the manufacture of pharmaceuticals, computers, electronics and aerospace. Medium-high technology industries include the manufacture of chemicals, motor vehicles, electrical equipment and armaments.

The growth in advanced manufacturing techniques will lead to an increase of new manufacturing methods which will require workers to have technical skills and to develop skills that are primarily ICT-based in:

1 digital techniques;

2 computing;

3 analytical thinking;

4 machine ergonomics;

5 understanding manufacturing methodologies (including design for manufacture, design for assembly and design for automation)

This is expected to create increased demand for highly-skilled engineers at graduate and intermediate levels.

In all of the advanced manufacturing industries for which data is available, there is a substantial increase in the number of professional jobs forecast to 2025; which generally sits alongside a decline in craft, plant and elementary occupations. The number of managers is generally forecast to grow as well; while the number of technicians and associate professionals will grow in some sectors (chemicals; electrical equipment; motor vehicles) and decline in others

Furthermore, education curricula have not, in the past, kept pace with the growing technological developments in the sector, compounding the incidence of skills shortages. The growth in advanced manufacturing will require workers to both sustain a good understanding of the skills required to utilise new ICT equipment and manufacturing techniques, as well as knowledge management skills. This will require broader training programmes, which integrate research with technology and manufacturing, from school level to graduate and post-graduate levels

3. METHODOLOGICAL APPROACH

The industry-oriented skills indicators for mechatronics technology provided to partner a reference for the designing of Edutronix module, that should enables the realization of a training path in the field of electrical - electronics, sensor technology, automation, robotics and mechanics **with a strong practical orientation**

The criteria taken into account in designing the module include 4 key elements:

the needs of enterprises, to align the skills of learners with the skills required by enterprises
the needs of students to increase their employability and mobility
the need of teachers to adopt new pedagocical approaches that encourage learning in the form of concrete meaningful experiences, challenging and arousing interest, to design curricula or part of them through the practical application of learning outcomes approach, to develop a common language between school and business
the need of vocational -training system to pursue the development of the equivalence of training programms and occupational profile in european countries.

Project partners, giving the difficulty of comparing the different training systems (see appendix 1) and their respective qualifications in mechatronic, have agreed to structure the module through the ECVET European Credit System for vocational education and training approach that makes it easier to describe parts of a qualification in a comprehensible way and therefore adaptable to the various educational and training contexts where the module will be applied.

The learning outcomes approach applied by partners, was supported by desk analysis, made by partners which highlighted that Ecvet instrument and its implementation in the 3 countries participating in the project, Poland, Spain and Italy has reached an advanced stage but there is still the need to work on practical application.
Desk analysis focused on the results obtained in the framework of European funded projects: “Quality by Units” Country Report Poland, “Mechatronics on the move”, Cedefop, ReferNet, Vet in Europe In particular Poland, Spain and Italy..

Therefore, the steps that have helped lay the foundation for designing the module are as follows:

- Need analysis, to identify the needs of the beneficiaries of the Edutronix module (direct and indirect)
- Desk analysis to identify the main area of intervention to draft the module
- Desk analysis on the training vocational systems of partners’ countries
- Drafting the framework of the module and its main features
- Identification of the methodological approach to design the module: learning outcomes approach.

Learning outcomes approach

Learning outcomes are statements of what a learner knows, understands and is able to do on completion of a learning process. Learning outcomes are defined in terms of knowledge, skills and competence.
Knowledge means the body of facts, principles, theories and practices that is related to a field of work or study. It is described as theoretical and/or factual knowledge;
Skills means the ability to apply knowledge and use know-how to complete tasks and solve problems. They are described as cognitive (logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, tools and instruments);
Competence means the proven ability to use knowledge, skills and personal, social and methodological abilities in work or study situations and in professional and personal development. It is described in terms of responsibility and autonomy

A unit of learning outcomes (also called "unit" or "module") is a component of a qualification consisting of a coherent set of knowledge, skills and competence that can be assessed and validated
This presupposes that the units of learning outcomes are structured comprehensively and logically and that they can be examined. Units of learning outcomes can be specific to a single qualification or common to several qualifications and may also describe so called additional qualifications which are not part of a formal qualification or curriculum.

A unit of learning outcomes should be designed in such a way as to provide a(n almost) consistent and structured learning process, with agreed coherent learning outcomes and clear criteria for assessment.
In a learning agreement the partner institutions and the learner agree on corresponding units of learning outcomes.
The following criteria are intended to support the partners determining the units of learning outcomes:
Units of learning outcomes should be designed in such a way that they can be completed as independently as possible of other units of learning outcomes..

Units of learning outcomes should include all necessary learning outcomes, i.e. they should describe the intended professional competences as well as the necessary social and personal competences in this context.

Units of learning outcomes should be structured and dimensioned in such a way that the relevant learning outcomes can actually be achieved in the given time, i.e. during the period of mobility. Units of learning outcomes should therefore not be too extensive.

More information to support partners determining the units of learning outcomes can be found in Appendix n° 2 of this report.

4. DESIGN OF THE INTERACTIVE MODULE

The module will be contextualized by Centrum Ksztalcenia Zawodowego in Wysokie Mazowieckie,(**technical vocational Institute)** within the Qualification **Mechatronics Technician** -4-year period of teaching

Qualification

- E19 Designing and programming of mechatronic devices and systems

			Class and semester								Number of hours	
		Compulsory educational classes professional education	I		II		III		IV		weekly in a four-year period of teaching	in a four-year period of the teaching
			I	II	I	II	I	II	I	II		
Subjects in professional theoretical education	1.	Electrotechnology and electronics	2	2	4	4	2				7	210
	2.	Technologies and mechanical structures	3	3	6						6	180
	3.	Pneumatics and hydraulics			4	2	2				4	120
	4.	Mechatronic devices and systems				2	4	5			5,5	165
	5.	Economic activity in mechatronic industry							2		1	30
	6.	Foreign language in mechatronic industry							2		1	30
		Total number of hours	**5**	**5**	**14**	**8**	**8**	**5**	**4**	**0**	**24,5**	**735**
Subjects in professional education – practical classes	1.	Measurements in the electric and electronic systems			4	4					4	120
	2.	Techniques of manufacture and mechanical structures	5	5							5	150
	3.	Assembly of pneumatic and hydraulic systems				6	4				5	150
	4.	Operating of mechatonic devices and systems					3	5			4	120
	5.	Designing and programming in mechatronics						5	8		6,5	195
		Total number of hours	**5**	**5**	**4**	**10**	**7**	**10**	**8**	**0**	**24,5**	**735**
Total number of hours of professional education			**10**	**10**	**18**	**18**	**15**	**15**	**12**	**0**	**49**	**1470**
Hour for the use of the headmaster									2		1	30
Number of hours per week of compulsory educational classes			33	33	35	35	34	34	31	31	133	3990
Number of hours per week of educational classes			35	35,5	37,5	37	36,5	36	33	33	141,7	4251
Professional practice for third grade students (4 weeks)								**160**				

The desk analysis on skills demand that has been carried out has allowed to single out **the main area, Electrics and electronics,** that has been considered as relevant with the aim of adapting the Mechatronic Technician curricola to the identified needs of the direct and indirect beneficiaries of the module

The area has been divided into:

Basics of robotics

Electro-technology and electrics

Control systems

Edutronix module should comprises: basic sensors used in mechatronic systems and devices, basic pneumatic and hydraulic components, the basic electrical and electronic components.
An integral part of the module refers to programmable logic controllers PLC. Complementary elements of the module are a variety of objects that require control, such as: robots, models of machinery and equipment, models of traffic lights at road junctions, models of passenger lifts, etc. These facilities controlled by the PLC or microcontrollers would make it easier for students to learn the skills of designing and programming of mechatronic devices and systems necessary to pass the exam for qualifications (E .19 in Poland).

The whole module will be assembled to a consistent path**: a qualification " mechatronic technician", a training framework supported by an educational e learning platform, a toolbox ad a mobile application.**
Partners adopted blended teaching methodologies as well as diversified learning settings, integrating classroom, individual distant learning, practical learning with the guide of teachers who support and encourage work in team and collaboration and envisaging
The duration of the module is **60 hours**, but it could be adapted according to the needs of the trainees/ students
Educational e learning platform is the first tool directly creating Edutronix model, it includes theory from the respective branches of mechatronics, tests to check the knowledge, exercises and different self-study documents. Theoretical knowledge placed on the platform is presented in various forms such as PDF/Word documents , presentations, videos, instructions.

Another element directly creating Edutronix model is the **toolbox.** It enables the practical usage of the knowledge gained through learning platform and the construction of various forms of the robot, control and measurement systems. The toolbox includes tools such as:

a) arduino module, the heart of the robot or other control system

b) programming environment: S4A and Arduino, which will allow the programming of physical models based on the exercises derived from the educational platform or one's own ideas.

c) **mobile application** through which one will be able to program and control the robot or any other device created by the user. Such control may be conducted from anywhere.

d) **a set of physical components needed for construction of the robot**, manipulator or any other system of measurement or control. These two instruments are connected each other by the exchange of information. On the one hand the construction of the physical model based on the theoretical information placed on the learning platform, on the other hand a good understanding of the theoretical knowledge on the basis of practical exercises and tasks (construction of the robot, manipulator or any other system of measurement or control).

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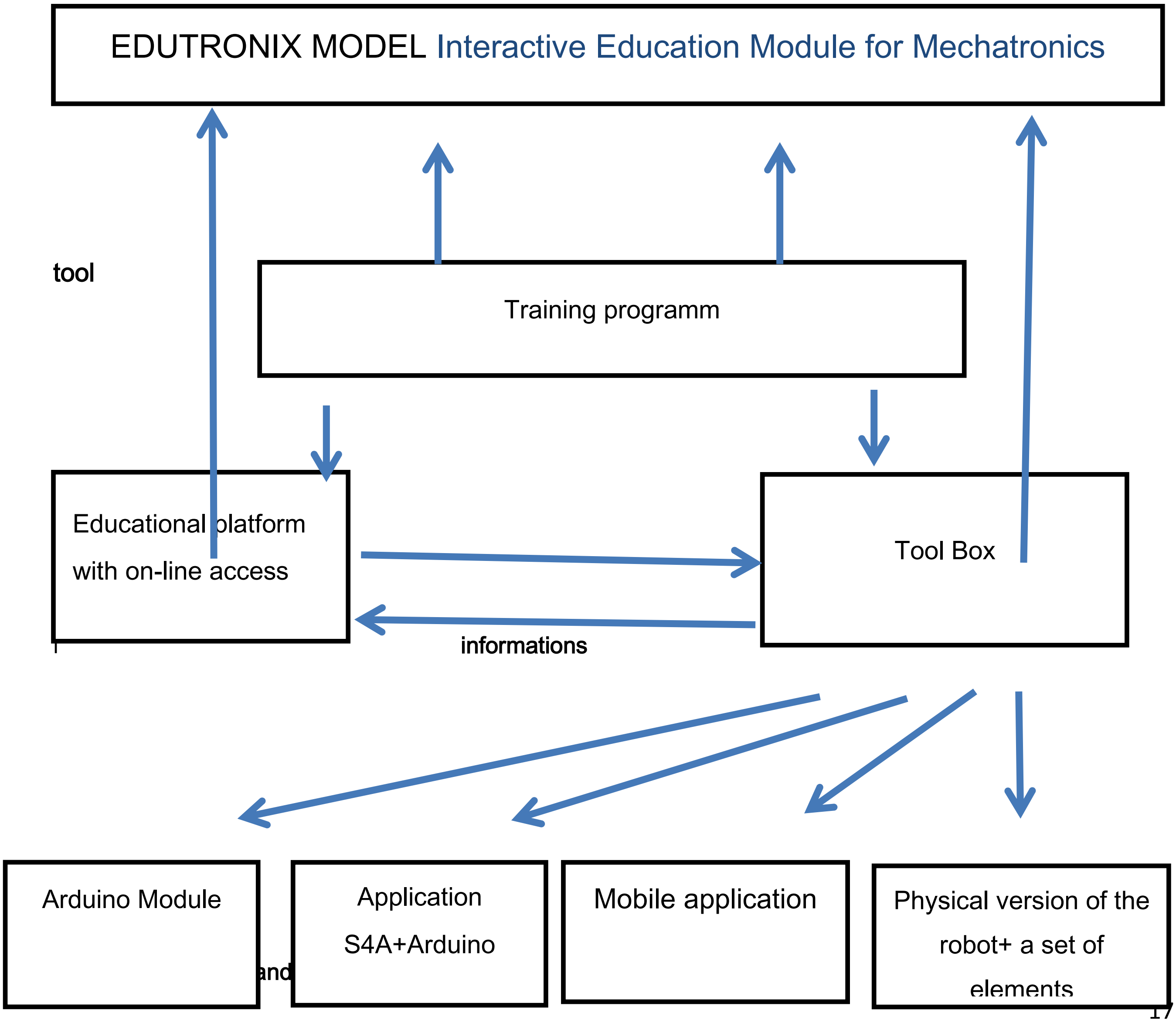


At the time of writing the report ,partners have defined the 3 main areas of intervention and packaged them in training objectives and contents. The completion of the features of the path, will allow partners to design the module according to the learning outcomes approach.

The program focus on **Electrics and electronics** and is composed of :

Basics of electro-technology and electronics

Control systems and microcontrollers

Design and programming of control systems and robots

Title	Mechatronics
Area	Electrics and electronics (E)
Qualification	E.19. Designing and programming of mechatronic devices and systems Qualification is a segment in the profession of **mechatronic technician 311410**
Target group (recipients of the course)	Students of vocational schools and institutes of lifelong learning preparing for work in a profession of mechatronic technician, everyone interested in the topic
Operational objectives of the course	Educational outcomes include (student should): – recognize and characterize basic electronic elements and systems – recognize and characterize basic electric elements and systems – recognize and characterize basic mechatronic elements and systems – choose the appropriate mechanic, electric or electronic elements to a given control and measurement systems or a robot – build control and measurement systems as well as different forms of a robot – use the application designed for the programming of microcontrollers (Arduino, S4A) – use the programming platform ARDUINO; – program designed control or measurement systems, as well as various forms of a robot – explain the structure and principles of operation of created control and measurement systems as well as various forms of a robot – explain the structure and principles of operation of programmes designed and created for microcontroller

Time	**Number of hours in total 60**
List of modular units	JM 1 – Basics of electro-technology and electronics (10 hours) JM 2 – Control systems and microcontrollers (10 hours) JM 3 – Design and programming of control systems and robots (40 hours)

Title	Mechatronics
Module unit	JM 1 – **Basics of electro-technology and electronics**
Time	10 hours on-line
Requirements before	Beginning to perform activities student should be able to: – operate the basic concepts of electric al engineering and electronics such as: current, voltage and resistance – know the basic laws of physics, such as Ohm's law, the first and the se-cond Kirchhoff's law – know the units of basic electric quantities – distinguish the symbols of basic electric and electronic elements – read simple electric diagrams
Skills gained at the end of the course	In the end student should know how to: – select appropriate components to a given control system – calculate basic parameters of electrical and electronic components – explain the design and the principles of operation of the components of electric and electronic systems. – know the properties of electric and electronic components used for de-signing control systems and the robot – discuss the methods of operations of direct current engines, for ex ample stepper engines – draw simple electric and electronic diagrams – define concepts such as: low and high state – connect components to control systems or the robot
Educational material	Definitions from the field of electrical engineering and electronics: Resistors; Diodes; Capacitors ; Coils; Stabilisers; Rectifires; Transformers; Semiconductors;

	Transistors; Opto-isolators; Electric wires; Direct current engines; Voltage multipliers; Servomechanisms; Amplifiers;
Didactic aids	Educational platform
Educational methodology	Self-education using educational platform
Method of evaluation	Tests, questions

Title	Mechatronics

Module unit	JM 2 – **Control systems and microcontrollers**
time	10 hours on-line
Requirements before	Beginning to perform activities student should be able to: – Define Basic concepts of digital technology such as: binary and analog signals ; – Know the structure of control systems; – Classify microcontrollers; – Know different types of sensors; – Know the application of basic elements of control systems such as: button, sensor, breadboard; – Define the usage of digital displays.
Skills gained at the end of the course	In the end student should know how to: – Create simple control algorithms; – Know the Basic logical functors used in digital technology; – Discuss the functioning of digital combination systems; – Discuss the functioning of digital sequential systems; – Explain the construction and principles of operation of a given microcontroller (MICROPROCESSOR) – Characterize microprocessor system; – Name particular components constituting microprocessor system; – Explain the principles of operation and application of the components of microcontroller; – Read and convert numbers in various numerical systems; – Create control systems.
Educational material	Control systems; Numerical systems; Analog and digital systems; Microcontrollers (microprocessors); Breadbords Buttons; Digital displays Sensors;

Didactic aids	Educational platform
Educational methodology	Self-education using educational platform
Method of evaluation	Tests, questions

Title	Mechatronics
Module unit	JM 3 – **Design and programming of control systems and robots**
Time	40 hours (10 theory on-line + 30 practical education)
Requirements before	Beginning to perform activities student should know how to: – Know the programming languages applied for microcontrollers; – Know the basics of designing control systems – Have basic knowledge of communications networks such as: wire and wireless networks or bluetooth – Know the rules of configuration between programming applications and control or robotic system – Know the basic rules applied for programming of microcontrollers
Skills gained at the ends of the course	In the end student should know how to: – Design, build and program control system or a robot on the basis of exemplary instructions – Design, build and program very own control or robotic system Discuss the construction and purpose of Arduino programming platform; – Use the application designed for the programming of microcontrollers, S4A; – Write a program in the S4A application – Know the basic commands and instructions used in the C programming language – Use the Arduino application designed for microcontrollers programming ;

	– Write a program for the microcontroller in C language, using Arduino app – Establish communications between Arduino and S4A apps and programming Arduino platform – Manipulate the robot or any other control system via mobile devices
Educational material	Principles of microcontrollers programming ; Principles of designing control systems and robots; Sample programmes for selected control and robotnic systems Programming platform (Arduino); Programming app (S4A I Arduino);
Didactic aids	Educational platform, toolbox.
Educational methodology	Self-education using educational platform, Practice using a simulator of programs creating, programming, simulation of action
Method of evaluation	Tests, questions, creating a typical robotic program

Learning outcomes approach

Partners were not familiar with ECVET, but saw the added value of applying the principles

The following dscription is the first step towards the adoption of all ECVET components.

The three UNITS are described in terms of Knowledge, skills and competnces

Name of the Unit:	**Basics of electro-technology and electronics**	EDUTRONIX

Reference to the qualification:	**Designing and programming of mechatronic devices and systems**	
Area of work tasks: Understanding the basic concepts of electrical engineering and electronics	EQF-level: 5	PRK-level: 5

Description of the Unit:
In this unit the student/listener acquires knowledge of basic laws of physics used in electrical engineering and electronics Learns about the properties, construction and operation of components and systems used in electrical engineering and electronics Acquires the knowledge about the construction and principles of operation of servomechanisms and direct current engines.

Knowledge	Skills	Competence
He/she is able to: • Operate the basic concepts of electric al engineering and electronics such as: current, voltage and resistance • Know the basic laws of physics, such as Ohm's law, the first and the second Kirchhoff's law • Know the units of basic electric quantities • Distinguish the symbols of basic electric and electronic elements • Read simple electric diagrams	He/she is able to: • Select appropriate components to a given control system • Calculate basic parameters of electrical and electronic components • Explain the design and the principles of operation of the components of electric and electronic systems. • Know the properties of electric and electronic components used for designing control systems and the robot • Discuss the methods of operations of direct current engines, for ex ample stepper engines • Draw simple electric and electronic diagrams • Define concepts such as: low and high state • Connect components	He/she is able to: • Use the theoretical knowledge of electrical engineering and electronics in practice. • Use the knowledge of electrical engineering and electronics in variable conditions • Create a work schedule based on the knowledge of electrical engineering and electronics • Successfully communicate when discussing the operation of various phenomena, for example direct current engines • Improve one's professional skills • Perform professional tasks independently and in a team • Observe the rules • Interpret measurement results • Analyze electric

	to control systems or the robot	diagrams
Additional information: Materials for the Edutronix Project- Interactive module for teaching mechatronics		
Developed by: team of teachers from CKZ		

<table>
<tr><td colspan="2">Name of the Unit:</td><td colspan="2">Control systems and microcontrollers</td><td rowspan="2"></td></tr>
<tr><td colspan="2">Reference to the qualification:</td><td colspan="2">Designing and programming of mechatronic devices and systems</td></tr>
<tr><td colspan="3">Area of work tasks:
Understanding the basic concepts of control systems and microcontrollers</td><td>EQF-level: 5</td><td>PRK-level: 5</td></tr>
<tr><td colspan="5">Description of the Unit:
In this unit the student/listeners acquires basic knowledge of control systems such as: analog and digital signals, as well as numerical systems. Becomes acquainted with all the necessary information concerning the elements needed for the creation of control systems, such as: bread boards or sensors. Acquires the knowledge of the structure, properties and principles of operation of microcontrollers.</td></tr>
<tr><td colspan="2">Knowledge</td><td>Skills</td><td colspan="2">Competence</td></tr>
<tr><td colspan="2">He/she is able to:
• Define Basic concepts of digital technology such as: binary and analog signals
• Know the structure of control systems
• Classify microcontrollers
• Know different types of sensors
• Know the application of basic elements of control systems such as: button, sensor, breadboard
• Define the usage of digital displays</td><td>He/she is able to:
• Create simple control algorithms
• Know the Basic logical functors used in digital technology
• Discuss the functioning of digital combination systems
• Discuss the functioning of digital sequential systems
• Explain the construction and principles of operation of a given microcontroller (MICROPROCESSOR)
• Characterize microprocessor system;
• Name particular components constituting microprocessor system
• Explain the principles of operation and application of the components of mi-</td><td colspan="2">He/she is able to:
• Use the technical vocabulary concerning microcontrollers
• Use technical vocabulary concerning control systems
• Assess own's educational needs in the field of control systems and microcontrollers
• Analyze diagrams and control alghoritms
• Perform professional tasks independently and in a team
• Improve one's professional skills</td></tr>
</table>

	crocontroller • Read and convert numbers in various numerical systems • Create control systems	
Additional information: Materials for the Edutronix Project- Interactive module for teaching mechatronics		
Developed by: team of teachers from CKZ		

Name of the Unit:	**Design and programming of control systems and robots**		
Reference to the qualification:	**Designing and programming of mechatronic devices and systems**		
Area of work tasks: Designing and construction of control systems and robots Programming control systems and robots		EQF-level: 5	PRK-level: 5

Description of the Unit:
In this unit the student/listener acquires the knowledge of rules applied for programming of microcontrollers. Familiarizes oneself with information needed for the design and construction of control systems and robots. Acquaints oneself and works with Arduino programming platform. Uses programming apps such a: S4A and Arduino. Creates and programmes control systems and robots.

Knowledge	Skills	Competence
He/she is able to: • Know the programming languages applied for microcontrollers • Know the basics of designing control systems • Have basic knowledge of communications networks such as: wire and wireless networks or bluetooth • Know the rules of configuration between programming applications and control or robotic system • Know the basic rules applied for programming of microcontrollers	He/she is able to: • Design, build and program control system or a robot on the basis of exemplary instructions • Design, build and program very own control or robotic system • Discuss the construction and purpose of Arduino programming platform; • Use the application designed for the programming of microcontrollers, S4A; • Write a program in the S4A application • Know the basic commands and instructions used in the C programming language • Use the Arduino application designed for microcontrollers programming • Write a program for the mi-	He/she is able to: • Take responsibility for built and programmed control system and robot • Use one's designing and programming skills in various environments • Design and programme control systems and robots bearing in mind all the health and safety regulations • Work in a team and communicate effectively while using the Arduino platform • Create friendly environment while cooperating with

	crocontroller in C language, using Arduino app • Establish communications between Arduino and S4A apps and programming Arduino platform • Manipulate the robot or any other control system via mobile devices	other Arduino users. • Observe programming rules • Improve one's professional skills • Observe the assembly rules • Combine knowledge and skills from various technological fields.
Additional information: Materials for the edutronix Project- Interactive module for teaching mechatronics		
Developed by: team of teachers from CKZ		

Conclusions

The work carried out by the partners to date made it possible to create the framework conditions necessary for the development of Edutronix module.

It 'was a shared learning process that led to create the basis of the module.

Partners were faced with the challenge of agreeing on a common language and common terminology regarding contents and objective of the Edutronix module .

They got aware on the needs to create a better understanding between the education, training sector and labour market, and to create an adaptable and exploitable module in different European educational and training contexts

They therefore agreed to adopt ECVET principles and; as a first step, they described the module applying learning outcomes. Three UNITS were created:

Basics of electro-technology and electronics

Control systems and microcontrollers

Design and programming of control systems and robots

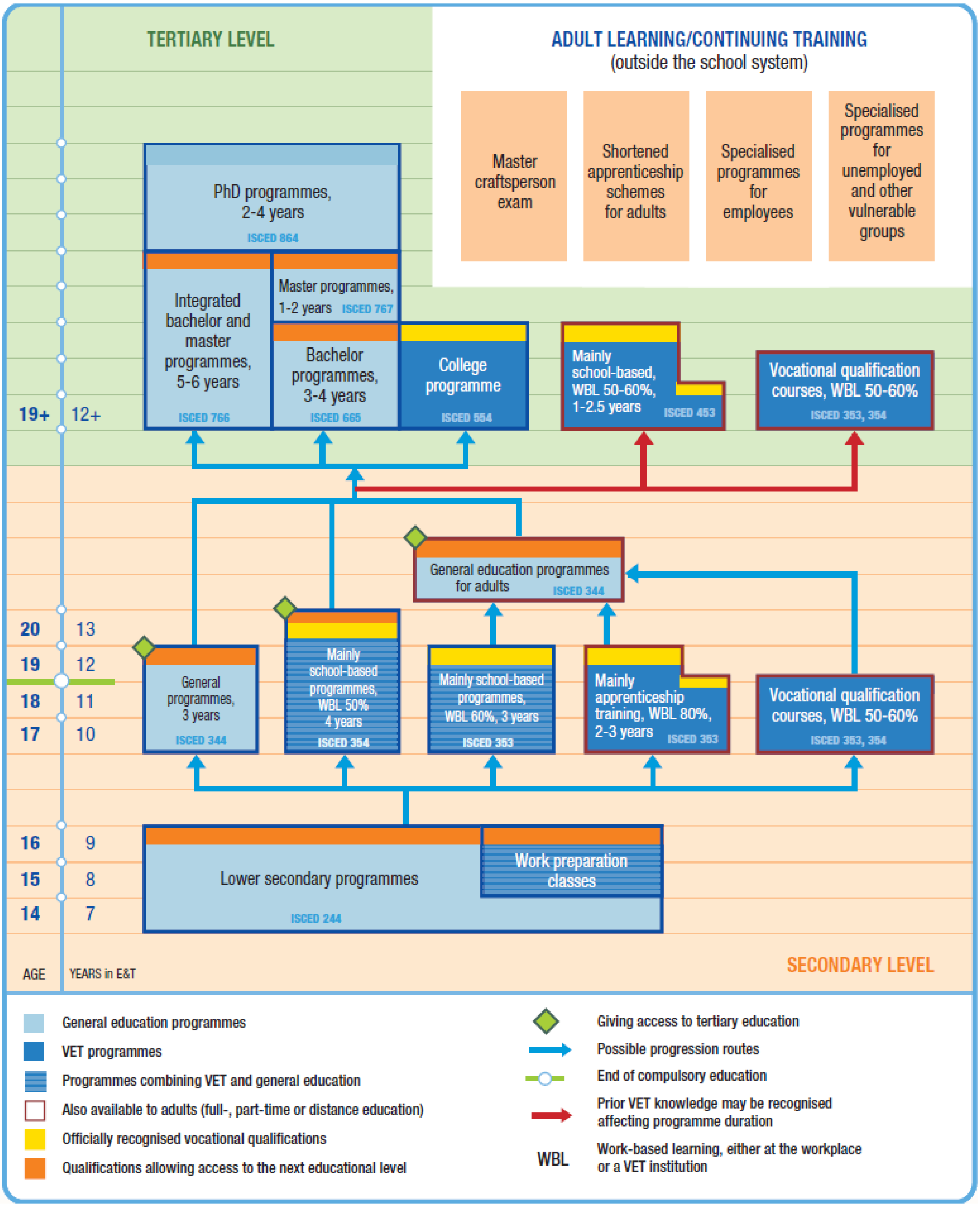
The achievement of learning outcomes is supported by an educational plattform with an on line access and by a kit of tools that enables the practical usage of the knowledge gained through learning platform, the construction of various forms of the robot.

Within intellectual output number six " An Innovative program using interactive educational module in mechatronics" the module will be completed and ready to use, in particular the Units will be improved and clear criteria of assessment will be added.

APPENDIX

1 National Education and training system framework in Poland , Spain and Italy

Diagram of the national education and training system in **Poland**



Primary (*szkoła podstawowa*) and lower secondary (*gimnazjum*) education is compulsory. It starts in the calendar year in which a child becomes six years old (7) and continues until graduation from a lower secondary school (usually at the age of 16) or until a person becomes 18 years old. Compulsory education can also be acquired in VET through training at work (apprenticeship; subject to separate regulations).

(

Upper secondary (general and vocational) education starts at the age of 16. It lasts 2-4 years depending on the type of school. Most vocational students complete their IVET at the age of 19-20.

The following types of schools provide initial upper secondary vocational education:

a) four-year upper secondary technical school (*technikum*);

b) three-year supplementary technical upper secondary school (*technikum uzupełniające*) (until 2015);

c) three-year basic vocational school (*zasadnicza szkoła zawodowa*);

d) three-year special needs school preparing for work students with mental or physical disabilities (*szkoła specjalna*).

In the 2013/14, there were 4 435 upper secondary vocational schools for young people. Vocational education is also provided in 1 to 2.5 year post-secondary non-tertiary programmes (szkoła policealna).

Different types of schools pursue different educational objectives. General secondary school (*licea ogólnoksztalcace*) prepares students for passing a *matura* exam and for pursuing their education in a higher education institution. Technical upper secondary school prepares both for the *matura* exam and entering the labour market. Basic vocational school and post-secondary non-tertiary school are focused on providing vocational qualifications. The curricula in vocational schools include practical training at workplace. In upper secondary technical schools, basic vocational schools or post-secondary schools, vocational education is provided for occupations included in the classification of VET occupations (MEN, 2007) which is consistent with the classification of occupations in the labour market (MPiPS, 2010). Primary (*szkoła podstawowa*) and lower secondary (*gimnazjum*) education is compulsory. It starts in the calendar year in which a child becomes six years old (7) and continues until graduation from a lower secondary school (usually at the age of 16) or until a person becomes 18 years old. Compulsory education can also be acquired in VET through training at work (apprenticeship; subject to separate regulations).

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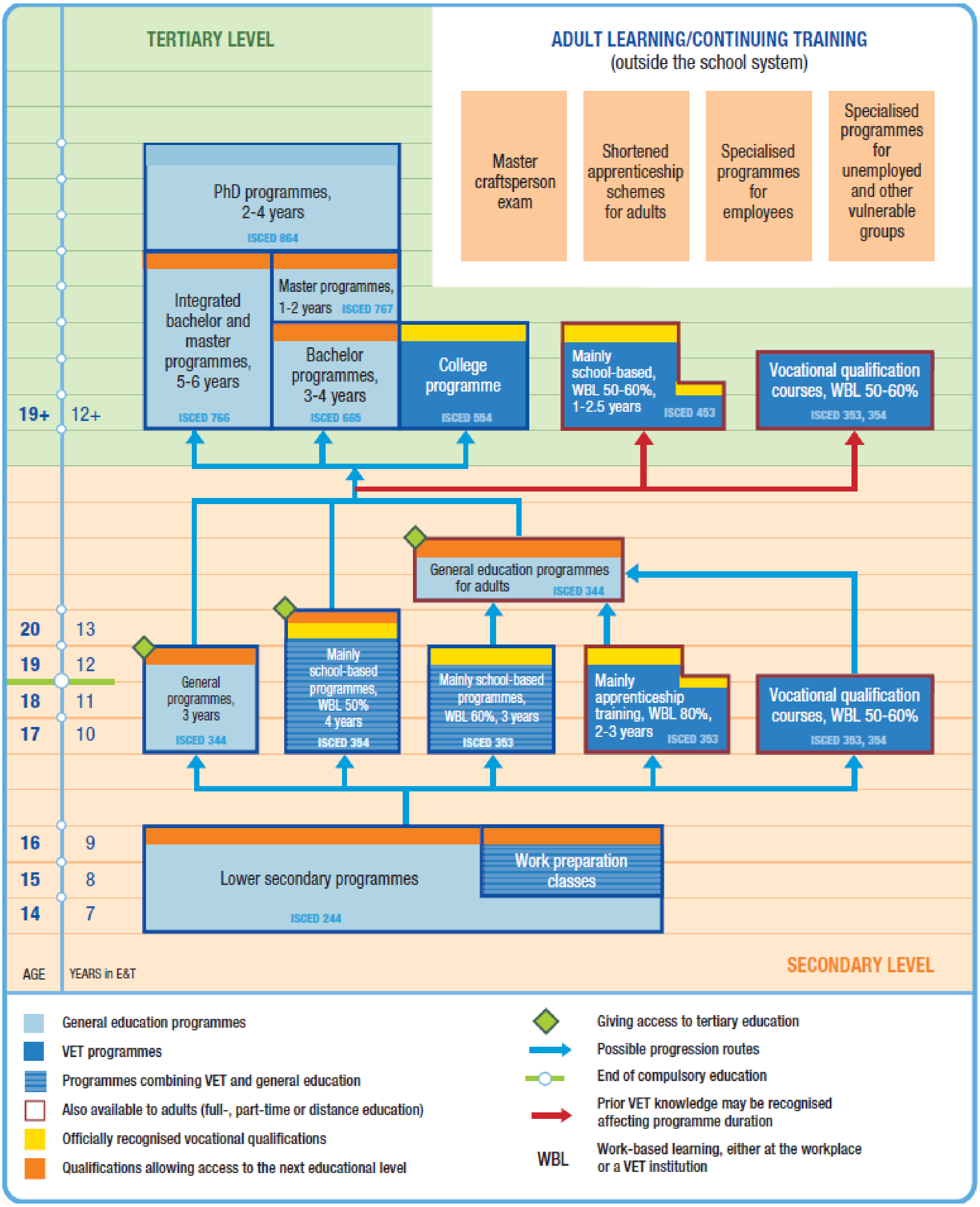
Diagram of the education and vocational training system in **SPAIN**



Education typically begins at pre-school and continues through to primary education (first stage of compulsory education) lasting six years, from 6 to 12 years old. Secondary education (last stage of compulsory education) lasts 4 years, until the age of 16. After completing secondary compulsory education, students obtain the lower compulsory secondary education certificate (Graduado en Educacion Secundaria Obligatoria (ESO)ISCED 2) which is a requirement to access upper secondary education (post obligatory), both the general Baccalaureate (BachilleratoISCED 3), and the vocational option (Intermediate VET diploma programmes ISCED 3)

Entry opportunities have been opened to those students who left the education system without an essential basic qualification. There are entry tests to pper secondary education, based on cetain age requirements, for both Bachilleratoand VET Diploma programmes (with certain age agreements. Bachillerato gives direct access to Higher VET diploma programmes (ISCED 5) and,via a university entrance exam, to university studies (ISCED 6). Likewise, Higher VET Diploma programmes can give access to university studies, depending also on demand and available slots.

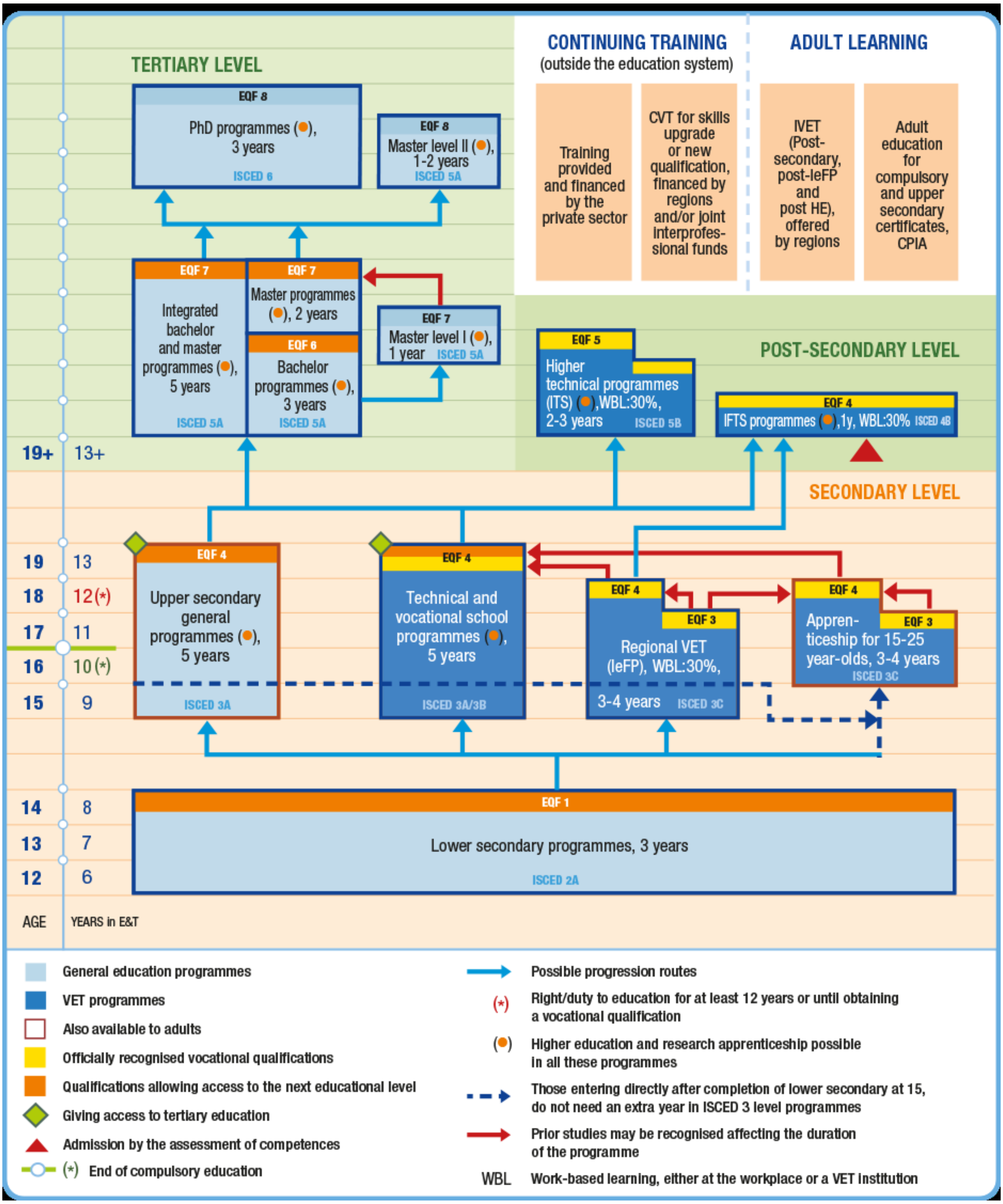
Both types of qualifications and doctoral studies (ISCED 6) are included in the Spanish Framework for Higher Education () (Marco Español de Cualificaciones parala Educación Superior,MECES) created in 2011. All VET programmes within the education system, at basic, intermediate or higher levels, have a minimum of 2,000 teaching hours split into two academic years according to the different sectors or fields grouped into professional branches

In agreement with the LOMCE, the newly passed law on education, the Initial Vocational Training Programmes (PCPIs), were withdrawn in September 2014 and consequently, a new level of vocational training was implemented, the so called Basic VET, covering so far 21 different diploma programmes. According to information and data provided by the Autonomous Communities, the number of enrolled students amounts to 34 688 students during the 2014-2015 academic year for the whole of Spain.

The target group for this training level is students aged 15 years, having completed their third year of Compulsory Secondary Education, and their teachers' team and parents joint assessment is to continue in the education system and enrol in Basic VET programmes. This training, unlike the previous PCPIs, is leading to official qualifications with academic and professional value and therefore, those students awarded with a Basic VET Diploma can access Intermediate VET programmes.

The flexibility of the system not only affects the vertical progression in VET, but also the horizontal flow between different educational programmes: The law allows students awarded with a Basic VET Diploma to obtain also the ESO diploma by passing the relevant core subjects at the final exam of Compulsory Secondary Education. Likewise, students awarded with Intermediate or Higher VET Diplomas may obtain the Bachillerato Diplomaby passing the relevant core subjects corresponding to the option chosen at the final exam of Bachillerato

Diagram of the education and vocational training system in **ITALY**



Secondary education in Italy lasts eight years and is divided in two stages: *scuola secondaria di primo grado* (lower secondary school), also known as *scuola media*, which corresponds to the middle school grades, and *scuola secondaria di secondo grado* (upper secondary school), which corresponds to the high-school level.

The *scuola secondaria di secondo grado* – formerly known as "scuola media superiore" (high school) – lasts five years (even though some *istituti professionali* might offer a professional certificate after three years). Every tier involves an exam at the end of the final year, called *esame di maturità*, required to gain a degree and have access to further university education. Any type of secondary school that lasts five years grants access to the final exam, called *esame di maturità* or *esame di stato*; this exam takes place every year between June and July.[1] It is designed to give students the skills to progress to any university or higher educational institution.[2]

For historical reasons, there are three types of *Scuola secondaria di secondo grado*, subsequently divided into further specializations.

Liceo (lyceum), **Istituto tecnico** (technical institute) **Istituto professionale** (professional institute)

- The education given in an *istituto tecnico* (technical institute) offers both a wide theoretical education and a highly qualified technical specialization in a specific field of studies (e.g.: economy, humanities, administration, law, accountancy, tourism, information technology), often integrated with a three-six months internship in a company, association or university, during the fifth and last year of study.Types of istituto tecnico include:
- **Istituto tecnico economico** (economic institute) – dedicated to economics and management, offers a broad theoretical education oriented toward specific subjects, such as law, economy, politics, and accountancy; it comprises two sub-types:
    - *Amministrazione, finanza e marketing* (administration, finance and marketing) – which specialises in economy, law, accounting, political sciences, management and marketing
    - *Sistemi Informativi Aziendali* (IT) – which specialises in IT and Information Systems
    - *Turismo* (Tourism) – which specialises in tourism and related topics
- **Istituto tecnico tecnologico** (technological institute) – specialized in: technology, informatics, electronics, chemical industry, biotechnology, construction management, geotechnics, fashion; it comprises nine sub-types:
    - *Meccanica, meccatronica ed energia* (mechanics, mechatronics and energy)
    - *Trasporti e logistica* (transport and logistics)
    - *Elettronica ed elettrotecnica* (electronics and electrical engineering)
    - *Informatica e telecomunicazioni* (IT and telecommunications)
    - *Grafica e comunicazioni* (graphics and communications)
    - *Chimica, materiali e biotecnologie* (chemistry, materials and biotechnology)
    - *Sistema moda* (fashion system)
    - *Agraria, agroalimentare e agroindustria* (agriculture, agro-food and agro-industry)
    - *Costruzioni* (building

APPENDIX 2 LEARNING OUTCOMES – Basic GUIDELINES

The following **criteria** are intended to support the partners determining the units of learning outcomes:

Units of learning outcomes should be designed in such a way that they can be completed **as independently as possible** of other units of learning outcomes. In individual cases, this can lead to redundancies when describing several units, i.e. competences may be listed in unit B which are already part of unit A. This does not preclude those parties involved in a mobility partnership from agreeing in advance on the competences/units of learning outcomes which the learner has already achieved.

Units of learning outcomes should include **all necessary learning outcomes**, i.e. they should describe the intended professional competences as well as the necessary social and personal competences in this context.

Units of learning outcomes should be structured and dimensioned in such a way that the relevant learning outcomes can actually be achieved in the given time, i.e. during the period of mobility. Units of learning outcomes should therefore not be too extensive.

Units of learning outcomes should be **assessable**. Orienting units of learning outcomes towards occupational activities and tasks makes it easier to determine assessment criteria.

What is to be taken into consideration when formulating learning outcomes?

Basically, learning outcomes should be formulated in such a way as to be understandable and thus "manageable" for all those involved.
This means that the partners define the terminology which they use (perhaps in the form of their own glossary) and choose a reference system (e.g. EQF).

The partners should consider the following points when formulating learning outcomes:
Learning outcomes refer to vocational qualifications (in the sense of assessable vocational competences), not to the individual's specific development of vocational competence.

The learning outcomes which are to be described are based on the learning achievements of an average learner. Learning outcomes are described from the perspective of the learner (not from the perspective of the instructor). Learning outcomes do not describe the learning target or the learning path, but the result following the completion of a learning process.

General training plans, framework syllabuses, curricula, examination regulations or qualification profiles can form the basis for describing learning outcomes in transnational mobility. However, these can also be generated from work processes.

Learning outcomes should be verifiable and assessable. Learning outcomes should be described in as concrete terms as possible so that it can be determined within the framework of an evaluation process whether the learner has achieved the learning outcomes. The learning outcomes should, however, be formulated in such a way as to also enable the learners to judge whether the results have actually been achieved.

The nature of the learning process and the learning method itself are not relevant for the description of learning outcomes.
As a general principle, there should neither be too many nor too few learning outcomes.

How are learning outcomes formulated?

The following basic principles can make it easier to reach an understanding between the mobility partners when describing learning outcomes:

Use of active, clearly understandable verbs Verbs should describe measurable or observable actions, e.g. "explain", "represent", "apply", "analyse", "develop", etc. It may prove useful to develop a taxonomy table. (Table 1 contains a list of verbs which can be used when formulating learning outcomes. This can be supplemented by job-specific verbs depending on sector and domain.) Verbs such as "to be familiar with" should not be used.

Specification and contextualization of the active verb It should be described what the knowledge and ability refer to in concrete terms, or what type of activity is involved. The learning outcomes formulation should consist of a verb and the related object as well as an additional (part of a) sentence describing the context.

Avoiding vague, open formulations Learning outcomes should be described briefly and precisely, complicated sentences should be avoided, learning outcomes should not be formulated in too general or in too concrete terms; clear (simple and unambiguous) terminology should be used as far as possible. Not: He/She knows the regional products and is able to prepare simple meals.

Orientation towards minimum demands for achieving learning outcomes Learning outcomes should comprehensibly describe the minimum demands for achieving/validating a unit of learning outcomes, i.e. all learning outcomes which are necessary for fulfilling the tasks in the sense of a complete vocational activity should be listed.

Qualifications-/competence level is described comprehensibly Formulations, particularly verbs and adjectives should reflect the level of qualification/competence (EQF or sectoral framework) of a unit of learning outcomes. The learning outcomes description should comprehensibly depict whether the vocational competences can for example be applied under supervision, autonomously or responsibly and competently.

How are learning outcomes described?

The title of a unit of learning outcomes should be clear and comprehensible for all persons involved (partner institutions, learners) and it should reflect the content of the unit. Here are examples

<table>
<tr><td>Name of the Unit:</td><td colspan="3">Making of a cutting tool</td><td rowspan="2"></td></tr>
<tr><td>Reference to the qualification:</td><td colspan="3">Level 3 – Mechanical Engineering</td></tr>
<tr><td colspan="3">Area of work tasks:
Making of a cutting tool for special applications</td><td>EQF-level: 4</td><td>DQR-level: 4</td></tr>
<tr><td colspan="5">Description of the Unit:
The apprentice professionally designs cutting tools for CNC lathes and milling machines, he/she develops a CNC program in order to produce the tool. The finished tool will be checked for dimensions and quality. Health and safety regulations in engineering workshops will be applied during the production process. He/she produces the documentation including drawings and results of measurements to be handed over to the customer.</td></tr>
<tr><th colspan="2">Knowledge</th><th colspan="2">Skills</th><th>Competence</th></tr>
<tr><td colspan="2">He/she is able to:
• Distinguish between different materials
• Assign the correct tool to machine certain materials
• Use the program to design the cutting tool
• Create CNC programs
• Use different measuring instruments
• Describe results in an appropriate way</td><td colspan="2">He/she is able to:
• Choose the required material
• Necessary tools (heavy duty steel, high alloy steel)
• Create a design according to technical requirements
• Design an appropriate CNC program and simulate the production process
• Download the program to the machine
• Produce the cutting tool following the health and safety regulations in engineering workshops
• Check the dimensions of the product
• Document the measurements and results according to industrial standards</td><td>He/she is able to:
• Handle the expensive and technically demanding equipment responsibly
• Take responsibility in the production of cutting tools according to engineer standards
• Create an appropriate documentation (in line with the industry standards) independently</td></tr>
<tr><td colspan="5">Additional information:
Rahmenlehrplan Industriemechaniker LF 8 - Fertigen auf numerisch gesteuerten Werkzeugmaschinen</td></tr>
<tr><td colspan="5">Developed by: <D. Gabel and I. Hoheisel, BBS Neustadt a. Rbge., SGS College></td></tr>
</table>

References

Cedefop, Vet in Europe, countries reports

Cedefop, European sectoral trends

Isermann R.: Integrierte mechanisch-elektronische Systeme. VDI-Z, nr 10, 1993.

Isermann R.: Mechatronische Systeme. Springer Verlag, Berlin, 1999.

Eu skills panorama 2014 Focus on advanced manufacturing

Impuls project E2 –VET Leonardo da Vinci

CBI, trends mapping in mechatronics