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

NEW METRO Project

embeddiNg kEts and Work based learning into MEchaTROnic profile

Project n. 600984-EPP-1-2018-1-IT-EPPKA2-SSA

Survey on mechatronic education and scenarios

National Report

Greece

Introduction

The NEW METRO project should consider emerging technologies and their development in each country with a clear purpose on the identification of skills gaps and in view of establishing an updated competence framework and international curriculum options. Comparing existing education/training supply with the emerging needs of the labour market is the starting point of the project, and a clear focus should be given to the review of existing surveys, articles and projects which have addressed this issue (implication of technology diffusion in the relevant sectors on emerging skills/competences needs) in the last three-four year (from 2015 to now. Starting from an overview of innovation technologies, as in the list provided during NEW METRO KOM, partners should focus on the following points:

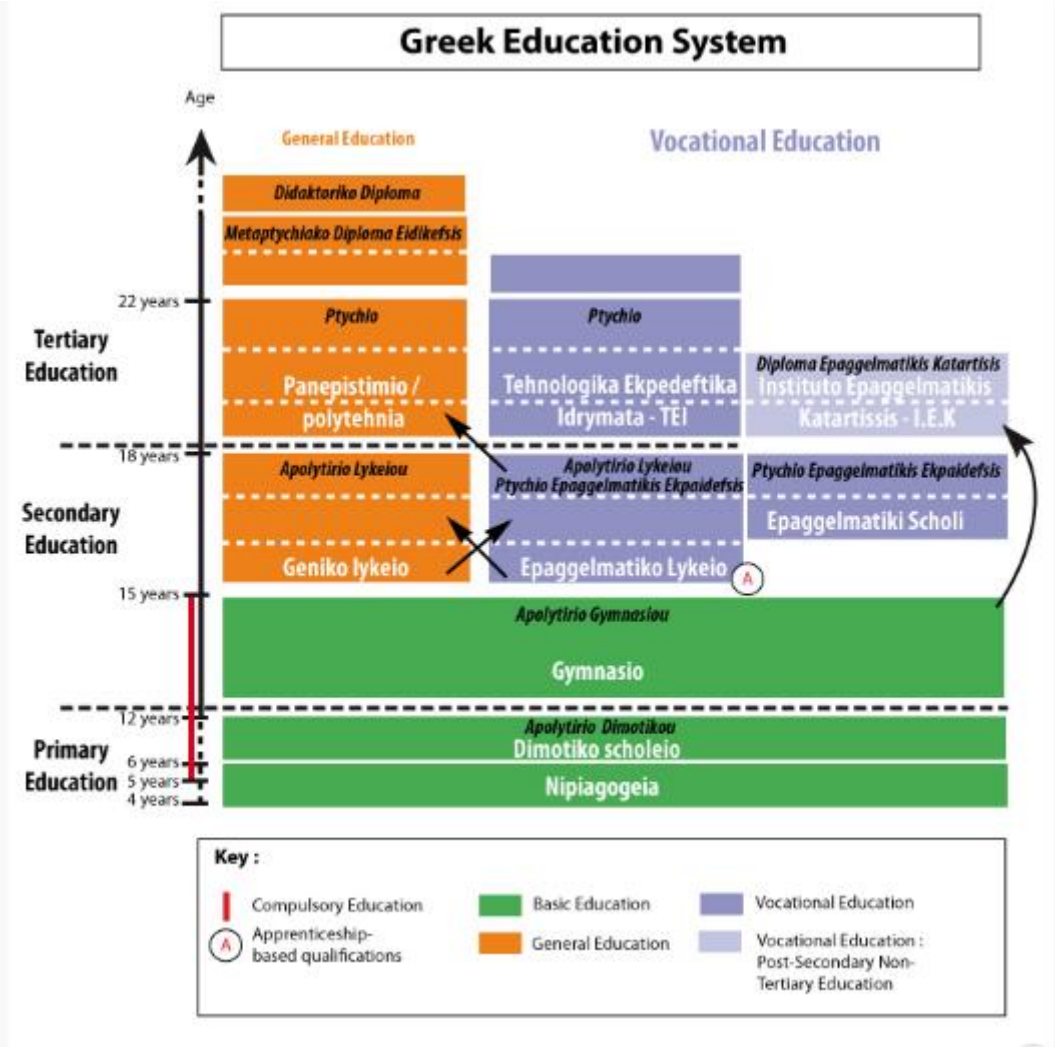
- **Supply of education**, training programmes related to the MECHATRONICS domain. It should be considered which courses are presently available in the country, with a focus on EQF level 5 (but looking also at secondary and higher education levels EQF4 and EQF6); are there plans to update curricula, what are the main technologies covered by the present and renewed curricula, which institutions are providing the courses and where in the country; is the education and training supply concentrated in the main industrial areas or diffused across the country? Are Curricula well expressed in terms of Learning Outcomes? Can a macro-analysis of their structure be provided (for example by a two page description of the main curricula identified, with teaching hours/discipline and internship identified).

- **Evolution of advanced manufacturing technologies** in the country and their implications for skills requirements (Short review of existing studies, statistics, articles covering the issue and possibly identifying the specific skills and competences requirements for existing workforce and young people to be recruited); the level of detail of information required on each technology should be established considering the relative competence of the partners staff in this domain; attention should be paid not only to qualitative developments but also to the employment dynamics in the relevant sector(s).

- A SWOT analysis of the present education/training provision in relation to the **existing and emerging demand of skills and competences** (e.g. mechanisms for updating study programmes, existing partnerships between education and industry, flexibility in the adaptation of study programmes, extent of dual learning and work-based learning, attractiveness of careers in the sector for students and their families, availability of modern equipment and competent teachers). The SWOT analysis should contain a few paragraphs of conclusions/recommendations and will be used for the focus group sessions for validation.

1. Overview on existing vet curricula In Mechatronics

The follow scheme is to recall the Greek Education System. This report is structured in sections. The use of sections makes it easy for the reader to jump straight to the information they need.



The specialty of “Mechatronic Engineering” combines knowledge of engineering, electronic and digital control, and has as its object the design and manufacture of modern industrial products, vehicles and motorcycles that meet the needs of modern man.

The professional graduate has the cognitive background and the skills required to perform the necessary maintenance, adjustment, diagnosis and repair of the mechatronic systems of all types of vehicles and motorcycles.

The rapid development of the automotive systems used in the automotive industry and their contribution to global economic growth in recent years place the “Mechatronic Engineer” at the forefront of technological developments and establish it as a necessary link for the smooth operation of automotive industry of Transportation.

The Greek educational system provides studies in mechatronics in follow levels:

A. VET Systems (level 5)
B. Mechatronics courses within the curriculum of other fields in the Universities (or Technological Educational Institute)
C. Master's Degree (level 7)

Mechatronic engineering may be employed in a wide range of industries or as mechatronics specialists may be employed in mechatronics area such as machine and tool design and production, biomedical and medicine technology (healthcare), energy production, mining and agriculture, manufacturing and automation and marine engineering

2. Education in Mechatronic

Certificates

Graduates of the specialty "Mechatronic Technician" after the successful completion of their training at the VET. Receive a Vocational Training Certificate and after their successful participation in the initial professional qualification certification examinations conducted by EOPIPEP. Receive a Vocational Qualification Diploma of level 5 education. The Institute for Vocational Training graduates who have passed the initial VET certification exams carried out by EOPEP, until the issue of the diploma, receive a Certificate of Vocational Training Certification.

Duration of study

The attendance at IVT is five semesters in total, divided into four semesters of theoretical and laboratory training of a total duration of up to 1200 academic hours of specialization, in accordance with the approved curricula and in semester of practice or apprenticeship of total duration of 960 hours.

Lessons at Vets

- Organization, functioning and safety of the synergy – environment
- Electrical and electronic systems of motorcycles and motorcycles
- Mechatronic Design
- Applied Machinery
- Practical Application in specialty
- Structure and operation of computer units
- Power production systems
- Power transmission systems
- Data communication theory and systems network in vehicles
- Operation, repair and maintenance of a car
- Motorcycle functioning repair and maintenance
- Electrical systems for cars – motorcycles
- Diagnosis of car problems
- Diagnosis of motorcycles damage
- Dynamic vehicles

Professional specialty profile

The specialty Mechatronic Technician in Mechatronic Engineering aims to create highly trained techniques that will be involved in the design and manufactured of modern industrial products, vehicles and motorcycles that meet the needs of modern man.

Professional Tasks

A certified Mechatronic Technician should be able to perform autonomous, timely and responsive technical work on the vehicle to know and perform:

- Functional connection and interaction of car systems.
- The basic principles of the diagnosis process.
- The auto-diagnosis systems of the car.
- The special equipment of his specialty.
- The criteria for choosing the special equipment of his specialty.
- Carries out diagnostic tasks on all car systems.
- It evacuates, recovers, and fills up refrigerant in an air condition.
- Ensures smooth operation of car systems.
- It takes all the necessary health and safety measures in the exercise of its functions.

Mechatronic in Universities

The Graduate Program in Mechatronics offers to its graduate's strong scientific background, experience and expertise on issues that require integrated synergy of Electronics, Engineering and Digital Control.

In Greece, although there are organized undergraduate engineering programs, its teaching is found in several similar fields of science. For example, in sections such as:

- Production Engineering and Management
- Mechanical & Mechanical Engineering
- Technology of Agriculture and Technology
- Automation Engineering
- Electronic engineers

include in their curriculum courses focusing on mechanical engineering such as:

- Mechatronics
- Mechanical Systems
- Agricultural Mechatronics
- Agro-Mechanics
- Scanning Machinery and CNC Planning Tools

Program Objectives

This program is a 3-semester master program and is addressed to graduates who want to gain experience in the design and implementation of efficient, economical and reliable systems and products by uniting the principles of mechanics, electronics, and computing. It covers various subjects in the areas of electronics, microprocessor-based design, data acquisition, power systems, mechatronic systems design, mechatronic behavior, and materials.

The Program is fully recognized by the Greek State

Graduates of the program can choose a wide range of career paths, as there is high demand for professionals who can combine the disciplines of mechanics, electronics and microprocessors, and cover the needs of most small businesses as well as large corporations.

The main objectives of the Department of Electrical and Computer Engineering are:

- Providing high-level postgraduate studies.
- Providing knowledge in the modern developments of Mechatronics.
- Synthetic Approach to Electronics, Mechanics and Digital Control for Product Design and Processes.
- Training of scientists with the required skills for successful careers in the private, public and academic fields.

Courses at Master

1st Semester

- Sensors and Signal Processing
- Mechatronic Behavior
- Microcontrollers and Logic Programming
- Power Electronics and Drivers
- Materials Technology

2st Semester

- Industrial Controllers
- Industrial Information Systems
- Industrial Robotics
- Material Design
- Hydraulic and Pneumatic Actuators
- Engineering of Mechatronic Systems

3st Semester

- Master Thesis
- Mechatronics Project Design

Mechatronics Project Design

- Mechatronic design process
- Product and process design applications
- Advantages of Mechatronic design approach
- User requirements specification
- Standards and safety regulations
- Embodiment design
- Prototyping and testing
- Reliability and productivity
- Ease of manufactured and minimization of capital and running costs
- Minimization of pollution and waste products
- Evaluation of design procedure.

Courses within other fields in the Universities

In Greece, although there are no organized undergraduate programs, mechatronics courses is teaching is in various relevant scientific fields. For example, in departments such as: Engineers of Production and Management, Mechanical Engineering & Automation, Electrical Engineers, included in their curriculum courses focusing on mechatronics such as:

- Mechatronics,
- Mechatronic Systems,
- Introduction to mechatronics
- Agricultural Engineering,
- Agro-Mechatronics,
- Design Machine Parts and Programmable CNC Tools
- Agricultural mechatronic

3. Are Curricula well expressed in terms of Learning Outcomes?

Greek educational system provides mechatronic curriculum into three levels:

- Higher education programs
- Vocational education and training programs (upper secondary schools)
- Two years' programs

Mechatronics curriculum in Vocational Training Institutes

The attendance at Vocational Training Institutes is five (5) semesters, divided into four (4) semesters' theoretical training and laboratory training of total duration which is up to 1200 teaching hours. According to the approved study programs and in one semester of Practical Exercise or Apprenticeship, total with duration of 960 hours

Brief Description of Professional Activities

The specially Mechnotronical Engineer in Mechatronic Engineerig aims to create excellence trained techicians who will be active in the design and construction of modern industrial products, vehicles and motocycles that meet the needs of the modern human.

Profession Profile

The certified Mechatronic Technician performs autonomous, timely and responsibly techniques work in vehicle, applying the manufacturer's general and specific instructions. The action is characterized by:

- -Time and resource savings
- Effectiveness
- Security
- Quality assurance
- Environmental Protection

The certified Mechatronic Technician has the professional capacity after the necessary adaption, be able to take over specific tasks assigned to it parts of the business where he works. He is also capable of exercising administrative duties in the field work.

The certified Mechatronic Engineer is able to adapt to the upcoming changes in the duties, because he has understood the necessity of continuous training.

Professional skills

The Certified Mechatronic Engineer should be aware of:

From Auto Diagnosis:

- Functional connectio and interaction of cars systems.
- The basic principles of the diagnosis process.
- Self-diagnosic system of the car.
- The special equipment of his speciality.
- The criteria fro choosing the special equipment of his/her speciality.

Certified Mechatronic Engineer must be able to:

From Auto Diagnosis:

- It correlates the functional connection and interaction of car systems.
- It applies the basic principles of the diagnosis process.
- The process of activating the auto-diagnosis of the car.
- Handles properly the special equipment of his specialty.
- Select the appripriate specialty equipment of its specialty.
- Carries out diagnostic tasks on all car systems.
- Refueling, recovering and refilling the refrigerant in an air condition system.

- Turns off the airbag and seat belts with pretensioner.
- Ensures smooth operaton of car systems.
- Takes all necessary hygiene and safety measures in the exercise of his duties.

From Practical Application:

Managed technical and administrative issues in spoken, written and electronic ways expertise.

Professional Tasks

A certified Mechatronic Technician should be able to perform autonomously, on time and on a timely basis responsible for technical work on the vehicle, applying its general and specific instructions manufacturer. His action is characterized by time and resources savings, efficiency, safety, quality assurance and environmental protection.

The certified Mechatronic Techician has the professional capacity after the necessary adaptation, be able to undertake specific tasks assigned to it parts of the business where he works. He is also capable of exercising administartive duties in the work field.

The certified Mechatronic Technician, because he has understood the necessity of continuous vocational training, is able to adapt to the upcoming changes in the duties.

Graduates of the specialty cover jobs in:

1. Service companies, which have to do with the repair and maintenance of cars.
2. Car dealerships.
3. Power generating companies with Manufactures Experience Register.
4. Vehicle inspection services and organizations.
5. Automotive industry.
6. Car Dealerships.
7. Roadside Assistance Companies.
8. Vehicle Technical Control Centers.

Training Program

	Semester	**A**			**B**			**C**			**D**		
A/A	**Lessons**	T	L	T	T	L	T	T	L	T	T	L	T
1	Organization, Function and Safety Surgery-environment	2		2									
2	Electrical and Electronic Elements Car – Motorcycle Systems	3	3	6									
3	Mechatronic Design		3	3									
4	Applied Machinery	2	4	6									
5	Practical Application in Specialty		3	3		3	3		3	3		3	3
6	Structure and Performance of Calculations Units				2	3	5						
7	Power Production Systems				3	3	6						
8	Power Transmission Systems				3	3	6						
9	Theory of Communication Data and Networks Systems in Vehicles							2	2	4			
10	Operation, Repair and Maintenance Car							2	5	7			
11	Operation, Repair and Maintenance Moto							2	4	6			
12	Electrical Systems for Cars - Motorcycles										2	3	5
13	Diagnosis of Car Problems											6	6
14	Diagnosis of Motorcycles damage											4	4
15	Dynamic Vehicles										2		2
TOTAL		7	13	20	8	12	20	6	14	20	4	16	20

Instructions for Certification Examinations

The graduate of the specialty Mechatronic Technician after the successfull completion of his training in VET. Participates in the initial vocational training certification exams conducted by the E.O.P.I.P.E.P. according to the provisions of No 2944/2014 K.Y.A. “Initial Certification System Vocational Training of graduates of the VET “

The certification of Initial Vocational Training of graduates VET based on examinations Theoretical and practical part. Vocational Qualification for Education and Training Level 5 in the specialty “Mechatronic Engineer” is entitled to whoever successfully completed the courses two parts of the exam.

Hygiene and Safety during Training

For the hygiene and safety of the trainees, all the provisions are complied with. For training in laboratories and in enterprises, the conditions are met standards for safety and hygiene in the specialty and the profession. In each case both for training in VET, in enterprises and laboratories as well as for practice training or apprenticeship beyond the observance of

safety rules in the specialty and profession, the safety and hygiene rules are in place by the laws of the State are respected.

Instructor Qualifications

As adult trainer is defined as the professional who has the formal and essential qualifications for the pursuit of his profession and the required certified educational competence for the general education and vocational training as part of lifelong learning regarding the currently in place Certified Professional Curriculum. The adequacy, constant renewal and updating of the qualifications of the trainers as well as the use of appropriate training methods and tools, including techniques adult education, are key prerequisites for ensuring its high quality provided training. For this reason, curricula include clear guidelines with regard to the qualifications of the trainers per course and with the necessary educational means, methodologies and tools.

New Two-Year Program

New Two-Year Programs will operate the new academic year 2019-2020 by Universities. Students of the two-year programs are selected without examinations based on the EPAL degree and / or the degree of the EPAL qualification. The attendance is free and lasts four academic semesters, including courses, workshops and internships. Upon successful completion of the program, five (5) degrees from the National and European Qualifications Framework are awarded. The two-Year Programs will teach tutors from the respective University that hosts the program, as well as external collaborating teachers with experience in the relevant subject.

Some of the academic Programs:

University of Western Attica

- Computing and Embedded Systems Engineer

- Shipyard Engineer

- Ship, Port and Watercraft Electrical Engineer

- Automation Engineer of Floating and Floating Facilities

University of Western Macedonia

- Robotics and Automation technician

- IT Application Technician

- Power Generator, Renewable Sources and Networks Technician

University of the Aegean

-Technical Naval Electrical Technology and Automation

- Sailing and Boat Engineers

Hellenic Mediterranean University

- Electrical Installations and Automation

- Production systems CAD/ SAM/ CNC

- Multimedia and Internet

International University of Greece

- Electrical Equipment and Safety Facilities Technician

- Mechatronic

- Technical Ship Systems

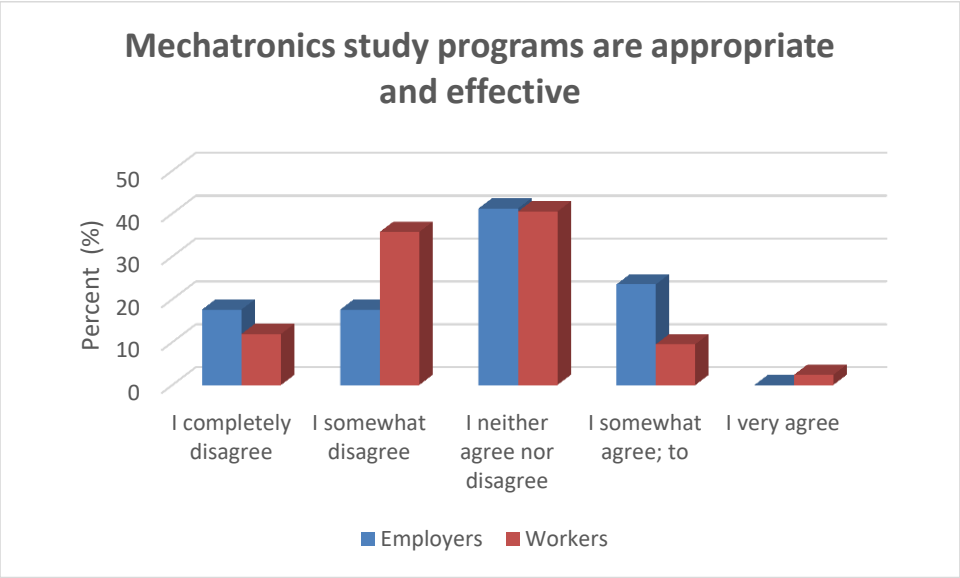


*Figure **Errore. Nel documento non esiste testo dello stile specificato.**-1: Survey of satisfaction about mechatronic study programs.*

Mechatronics provides the focus required to bring together different disciplines and create mixed-technology design. Traditionally, these have been housed in separate departments within an organization, which has blocked effective communications in the design process, with each discipline providing its own set of terminology and competition instead of collaboration. The combined approach naturally removes barriers and allows effective communications, thereby leading to an improved design process and a higher-quality end product.

As the mechatronics is a young discipline, the development of mechatronics discipline in Greece is still in its infancy. As shown in Figure Errore**. Nel documento non esiste testo dello stile specificato.**-1, the mechatronic study programs are in a midpoint on satisfaction survey.

4. Mechatronics and enterprises opportunities

4.1 The main needs that enterprise indicate

The candidate should be able to work in a team environment and coordinate the robotic development efforts, including system development, integration, and testing. Work closely with electrical, and software engineering team to develop systems from concept to production level. Lead the development of solutions in the areas of autonomous vehicles, UAVs (drones) and robotic systems. MSc. in Mechatronic Engineering or Electrical Engineering or related scientific field is required. Ph.D. is highly preferred. Degree may be in any of the multiple disciplines of Engineering including Software, Electrical, Mechatronic, Industrial, Computer, Mechatronic, etc. Proficiency and expertise in the use of one or more of the following tools: SolidWorks, AutoCAD, ANSYS Fluent. Understanding and consideration of aerodynamics and flight mechanics on UAV/Drone configurations Knowledge and experience in feedback control system, especially for flight control Significant hands-on experience developing, building, assembling and/or testing hardware Excellent English written and verbal communication skills Ability to work well in an engineering team environment. Ability to plan and prioritize tasks. Ability to work with outside vendors. Excellent oral and written communication skills

4.2 Priorities for the Business

Businesses under constant pressure to design and deliver machines don't always make time for engineers to collaborate or innovate. So, the mechatronic approach requires top-down leadership to schedule time to make R&D a priority. A simple, yet effective, entry ramp can be reworking an old design using the cross-discipline approach. When the team achieves specific benchmarks, such as a percentage improvement in reliability or energy efficiency, it should be rewarded so team members realize the importance of continuous improvement via collaboration. There must also be a plan to provide up-to-date and detailed project information to each engineer on the team.

Mechatronics is a relatively new concept, so it can be challenging to find engineers with solid educations or experiences in several engineering fields. A number of prominent engineering colleges offer courses in mechatronics, yet the term does not yet identify prospective candidates to fill real-world positions. Instead, firms continue to hire mechatronic engineers, electrical engineers, and programmers as separate entities. Therefore, the best plan to secure qualified mechatronic engineers is to create in-house resources. Bear in mind that engineers must also stay abreast of current technologies.

4.3 Priorities for the Educational Institutions

Mechatronics is a high-tech field, mechatronics is a “high-priority” occupation with rapidly expanding job opportunities. As more businesses advance their technologies and turns to sophisticated intelligent systems and robotics, mechatronics engineering will continue to grow in demand. Even manufacturing businesses considering a technology upgrade turn to mechatronics engineers in order to evaluate assembly line efficiency and costs. Many educational institutions are creating recent courses and educational programs so as to be as close as possible to the labor market.

Development Multidisciplinary skills. When the student receives a degree in engineering technology, he combines a wide range of skills in engineering, electrical engineering, computer science and control systems. In a sense, it's like winning three or four degrees of engineering in one. The multidisciplinary skills and knowledge you will acquire in an engineering program will give you the solid foundation you need to solve complex engineering problems. It will also give a great picture, flexibility and adaptability.

The theoretical pieces of theoretical studies may change, but students learn more easily when there is a practical part of the subject. The field of mechatronics is practical, so it makes sense only the mechatronics degree program to be practical. All engineering students put theory into practice in state-of-the-art laboratories. The student will work with the same components, systems and technology that are currently working in the field.

This mean that she will graduate with the confidence and experience she needs. Like FESTO modular LeamLine lab stations, national Instruments ELVIS trainers, fluids and hydraulics testing and measuring equipment, 3D printers, function generators, oscilloscopes and digital mustimeters, a dedicated lab for senior projects, latest generation computers and software, and more.

Every engineering student should have the opportunity to find an internship in the industrial, corporate or government organization that best suits your employment goals in mechatronic engineering mechatronics. Universities are designed to provide practical professional experience to solve real problems in a dynamic environment, offering improved employment opportunities on graduation. Each Higher Education Department works with several individuals to practice students in order to better integrate into work. They benefit from the experience of top mechatronics professors working in today's industries. In Higher Education, close relationships are established with teachers who provide basic knowledge that can only be acquired for years at work.

In the Educational Institutes' curriculum, they will not just learn theory because things work, they learn how to build systems on their own. Mechatronics students learn how to build, repair, plan and maintain smart machines and controls - the skills that employers are looking for. They also highlight real-world scenarios throughout the course of teaching, enabling engineering students to anticipate problems and create solutions that are directly applicable in the field.

Resources and equipment are important elements. The practical mechatronics experience that students will have in the workshops is invaluable - but the resources and equipment used by these workshops make the difference. It is necessary for the student to have a practical part and the practical part is made with new technology tools. That is what will also be used in the workplace later.

The title of Higher Institutes creates high professional standards. The engineering program incorporates teamwork and leadership skills while preparing students for lifelong learning, assumes personal responsibility and applies the highest professional and ethical standards to global engineering issues.

4.4 Expectations for the enterprises and the labor world

Equinor (formerly Statoil), as part of its efforts to strengthen its presence in renewable energy sources and particularly in the wind. The Norwegian giant of energy sees strong opportunities for the development of offshore wind farms in Greece, provided it adopts a regulatory framework soon for this technology. Equinor, one of the world's leading oil and gas producers, manages Hywind Park in Scotland. It is the first offshore wind farm in the world. It seeks to find a new renewable energy project to which it can invest. Among other things, he examines the investment opportunities in Greece, as confirmed by its Reuters official. Greece plans to increase the share of solar and wind power in electricity production to 48% by 2030 from 26% in 2016. The way to exploit the rich wind potential of the Greek seas and to build up domestic know-how in one of the most promising new types of wind farms will open next year with the first pilot competition for the installation of floating wind turbines in the country us.

4.5 Relevant emerging sectors

In an industry such as automotive where technology is pouring in at an unprecedented rate, incipient trends are multiplying like vehicles on the roadways at rush hour. Some trends for 2017 are inevitable given developments in recent years while others are more disruptive, bleeding into multiple areas. Consider how Uber disrupted the taxi market and fundamentally changed the transportation sector.

Trends emerge first among early adopters so watching their behavior is a good crystal ball. The good news for automotive OEMs and the vast array of related companies involved in this business is that there will likely be more funding available next year to develop new technologies embraced by these early adopters and refine current ones due to political and financial forces.

<u>Automotive suppliers discover blockchain</u>

In the automotive business, where the supply chain -- with all its potential for counterfeit parts and related issues -- is so important, blockchain technology can create a trusted, accurate protocol for this supply chain.

This establishes a system of checks and balances for the whole supply chain community, with cloud servers validating and recording everything.

Upgrades Wind Energy

In the coming years we are likely to see significant advancements in wind turbine technology. This will aid in wind becoming an even more widespread renewable energy source than it is today. It is also interesting to look at which energy types contributed to new capacity each year. Natural gas boomed in the early 2000s, and it appeared as if new coal was gone. Natural gas development slowed and renewable sources and coal then increased in capacity from 2007 to 2012. Now new nuclear and new coal are off the map, and renewable sources are taking the majority.

Concrete Tower Structures

Concrete wind towers are only just beginning to be explored and are likely to continue advancing due to the primary advantage of allowing tower segments to be built on site. This reduces cost and the challenges of moving the more traditional steel tower segments over long distances by truck. In addition, this allows for increased wind tower height. Already one such tower has been built in the USA in an Adams County, Iowa wind farm. It measures 377 ft from ground to hub. Another such facility has been constructed completely out of concrete towers. This project in South Africa is 138 MW and consists of 46 wind turbines.

This technology will continue to develop and improve for a few reasons. First, increased tower height allows for higher wind speeds, and thus more energy production. It also allows access to energy production in areas that may not otherwise be suitable for wind farms. Second, the decrease in costs associated with building the towers on site rather than long transportation of tower segments by boat, truck, and/or rail. And third, allowing the tower segments to be built on site also opens up the area available to wind farms that would otherwise not be accessible for transportation by road.

Larger Wind Turbines

Wind turbine size is also on the path towards continued growth in the future. This trend will to increase and is predicted by 2025 that turbines as large as 12–15 MW will be available, one example being GE Renewable Energy's 12 MW Haliade-X turbine. This also feeds into the next wind turbine technology that is likely to see progress, floating offshore wind. With these larger turbines, offshore projects are and will become even more economical.

Advancements in Floating Offshore Wind

Although to date only 15 MW of floating offshore wind turbines have been installed globally, this technology is likely to continue improving and become more widespread. One of the advantages over shallow water offshore wind is that it can be installed significantly further offshore, so that the turbines are not seen from shore, reducing potential push-back. Another advantage is that floating

wind turbines can be assembled on shore, towed out to their location, and attached to the sea floor with mooring lines. Although still expensive to date there is positive outlook that in the future when these wind farms are built at scale the cost will continue coming down.

Another major advantage of floating wind turbine is the resource availability. Currently, especially on the US west coast, there is not much availability for shallow water wind turbines. As floating wind technology advances this opens up significantly larger portions of area where offshore wind can be installed on both the west and east coasts of the United States.

As renewable energy adoption in the United States increases, wind energy continues gaining energy market share. Based on current technological development it seems likely that this trend will continue.

5. Barriers to the development

5.1 The main issues that hind the mechatronics education

Today, Technical Education is called upon to prepare its students as tomorrow's workers in a working and social environment characterized by:

- The change in all areas of human activity: occupations, products, methods, services, technological achievements, attitudes, etc. change at a rate that the ordinary citizen is difficult to monitor.
- The explosion of knowledge, mainly in technology and science: it is estimated that in the mechatronic engineering field, knowledge is doubled every five years.
- The radical change in the organization of work. From Taylorism, which required working executive bodies in routine roles, we are moving to flexible specialism, which needs multi-skilled workers with initiative, responsibility, imagination, resourcefulness and aesthetic perception.
- Occupational mobility: it is estimated that the current young person will change between three and seven occupations during his economically active life.

The problem of school failure is seriously worrying for all the advanced countries because routine routines - abolished by robotics, automation and computing - no longer exist where undeclared and skilled workers could be employed. Past and recent surveys have shown that school can take action to prevent and tackle school failure. The most serious problem with Technical Education in our country today is that it brings together the majority of the weaker students graduating from the Gymnasium without, at the same time, having the proper infrastructure in terms of books, updated education and curricula to enable these students to help them integrate smoothly into the knowledge society.

Surveys and experiments carried out in various Western countries have shown that pupils are more actively involved in approaching knowledge when given an energetic rather than

passive role, that is, when we begin to teach each student from where he is, rather than from where it should be.

Recent research has revealed that, insofar as each teaching takes into account and exploits the knowledge that students have so far achieved and the stimuli which, albeit incoherently, have accepted on a subject, then there is a greater chance of attracting students' interest in the follow-up.

To be effective, teaching to slim students should:

1. Do not long passive listeners. Participate in experiments, synthetic works, discussions, collaborative activities. Working in groups.
2. The courses should apply to situations in which they have chosen to pursue the profession. Thus, knowledge becomes more important. Meaningful activities are an incentive for learning. The teaching of mechatronic courses is linked to the profession wherever possible.
3. Speak sometimes specialists in the classroom and discuss with students.
4. Link school with society and especially with workplaces.
5. Students learn to read out-of-school books (in the case of their specialty), to look for information outside of the school manual, to evaluate information, to make small projects, to do small work, to devise solutions and to take initiatives and responsibilities.
6. Understand, not just memorize matter. So they will only remember and be able to spot differences, compare and answer crisis questions.
7. Let each student learn in their own way and at their own pace. Each student is different from everyone else. The persistence of starting all pupils from the same starting point, regardless of their knowledge, and learning the same things in the same way and at the same pace, leads not only to school failure a significant proportion of students. Therefore, there should be a variety of activities. It is necessary to identify the pupils' special abilities and interests. The new knowledge will be built upon them.

   How a module will be taught depends on the level of class. The same questions and exercises should not be given to all students. In order for us to have results, our demands from each student must be proportional to its potential. Tough questions discourage weak students and easy make the good student bored.
8. Find opportunities for encouraging comments. Disillusionment does not help the pupil at all. Not to mention students' mistakes in their writings in red. Instead, we should mark green in the right way.
9. Collaborate in learning.
10. Avoid grouping on the basis of skills or knowledge or performance. It works discouragingly for weak students.

5.2 Describe the current situation about education on work.

The learning approach for Mechatronics workers is in line with the following actions

- Student Practice
- Seminars, Conferences
- Summer school

Students Practice

The student can do practical training in maintenance, repair and control of all parts and systems of the car in the public and private sector, with a relationship of dependent or non-working.

- Service companies, dealing with car repair and maintenance.
- Car dealerships.
- Power generation companies with MEC (Manufacturers' Experience Register).
- Vehicle inspection services and organizations.
- Automotive industry.
- Car Dealerships.
- Roadside Assistance Companies.
- Vehicle Technical Control Centers (VTCC).

Seminars and Conference

The seminars aim to further deepen the skills of technical engineering. information on the new techniques and technologies that exist. The Hellenic Industrialists' Association creates a series of seminars, aimed at electricians and electronics presenters or supervisors of maintenance departments, who are engaged in automated systems and are knowledgeable of the electrical design and, more generally, of the automation philosophy.

For example, the purpose of a seminar is to transmit knowledge and skills to learners in the maintenance of a programmable automation application using the S7 PLCs. In particular, the seminar focuses on the structure of a station, the addressing of the variables of an application, the identification of input - output variables on the station, the basic differences between OB - FC - FB - DB, understanding the operation of a program, and , understanding key programming commands, and using tools: Hardwareconfiguration, Monitor, Variabletable, Symboltable, Upload, Download, Archive και Retrieve ενός project.

Summer schools

Summer schools have become so dynamic in recent years that they have transformed them into an institution. It is estimated that in the two-month period from June to July more than 50 summer schools were organized with participations exceeding 2.500, and students from Greece and the world. In fact, teachers indicated that in 2018 participation increased compared to 2016 and 2017, while the worst year was in 2015 due to political and economic developments (typically, the imposition of capital controls).

Summer schools are run by universities, research centers, scientific associations and schools. For example, the 3 rd. Pan-European Summer School on "Integrated Photonic Circuits for Optical Computer Interconnections" was organized in AUTH. Participants attended lectures in the rapidly expanding field of fiber optics and optical integrated circuits for applications in modern computing systems, data centers and supercomputers

In the world of biomedical science, those students participated in the second CGS Biomedical Engineering Summer Course. It is a summer educational program for students of high school and lyceum interested in broadening their knowledge in the basic concepts of biomedical technology and which is a continuation of last year's successful program organized for the first time by a Greek school.

5.3 Highlight the intervention of enterprises to support workers education

The types of training that are primarily applied in the glossary interface are:

Skills training

It is the most common form of education that takes place in two phases.

The first one recognizes the need or inadequacy through an integrated one

evaluation. In the second phase specific educational objectives are created, which after completion, are evaluated on the basis of predefined criteria.

Retraining

The ever-changing work environment requires constant updating of employees working on it. These employees are part of this type education, which focuses on providing them with skills that are necessary to enable them to operate in the changing environment.

Dysfunctional education

It is a form of education in which the employees of one enterprise are trained in performing tasks in different areas from the one who works. In particular, work rotation may take place, exchange of employees, but also the use of high - performance employees as trainers. Special attention is paid to qualifications and characteristics traits of people selected as trainers.

Group training

It is a form of training in which employees learn it usefulness of teamwork. This is achieved by working within it group training. They are trained in how conflicts are handled and interactions between members of the same group, how maximal is achieved communication and co-operation amongst team members.

Creative training

It concerns a method of education that guides individuals to solve problems, created in their workplace, with different and mainly innovative ways. In this form of education, the storm is

included ideas, in which participants are encouraged to speak openly without hesitation their ideas on a subject. Other techniques included in this form of education are:

- Proportions / transfers
- Free association
- Personal Ratio
- mapping the mind

Crisis training

It is a method by which workers acquire skills to face crisis which created in modern working environments, as well as to avoid conflicts and situations stress. This kind of education has been widespread in recent years as well work environments have become more complex

Service training.

It is the training method that is necessary for people who work in customer service. Through this training, the workers they realize the importance for the business of providing excellent customer service and fulfilling their expectations.

Elementary education

It is the method that tries to educate workers who do not meet the basic requirements required by the modern business environment. It is distinguished in general education which refers to the elementary training of the person and the functional that concerns the level of knowledge in a specific cognitive area, so that the individual can cope the necessary requirements of his job.

The frequency of training

The percentage of employees attending training programs as well the amount of education expenditure in relation to total wage costs has been reduced to a key indicator of the importance the business attaches to human resources. The annual amount of education expenditure reaches 1% total payroll to 44.80% of the sample companies, varies between 1-2% in 15.4% of enterprises, while it exceeds 2% cumulatively at 30.20% of enterprises

(Figure 1).

And here is a significant decrease in the last five years, since the respective rates ranged between 47%, 22% and 33% respectively in 2009.

Education as% of annual payroll cost

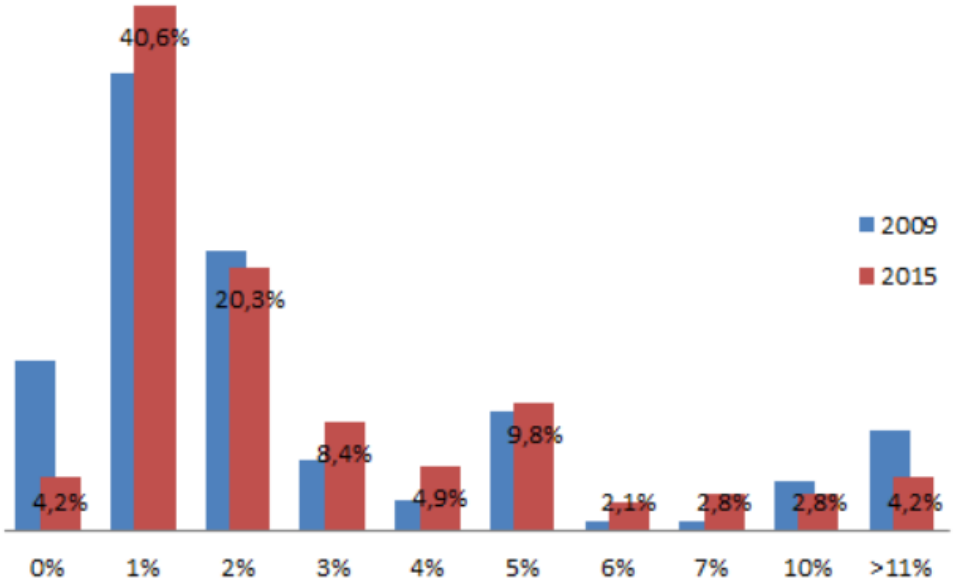


*Figure **Errore. Nel documento non esiste testo dello stile specificato.**-2: Annual expenditure on education as a percentage of wage bill*

If we look at education as a burden on the operating costs of the business over time, it is observed that compared to previous years, we have fewer businesses that have high budgets for education but also at the same time, more businesses that spend a very small proportion in proportion to payroll in training programs (44.4% of businesses spend below from 1.5% of the total payroll cost). Traditionally, education is considered to be the most vulnerable operation of human resources management in budget cuts and cost containment management of human resources.

Executive training days / year

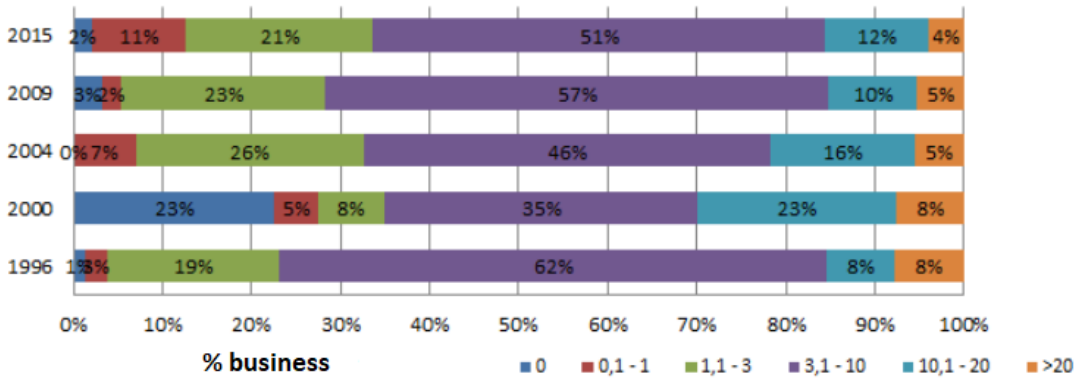


*Figure **Errore. Nel documento non esiste testo dello stile specificato.**-3: Training days per year, executives (Greece, over time)*

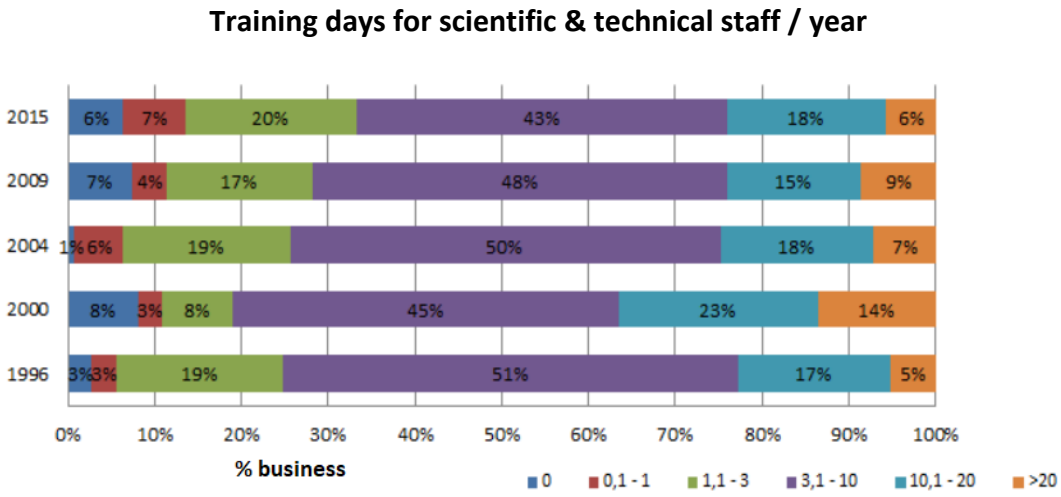


*Figure **Errore. Nel documento non esiste testo dello stile specificato.**-4: Training days per year, scientific and technical staff*

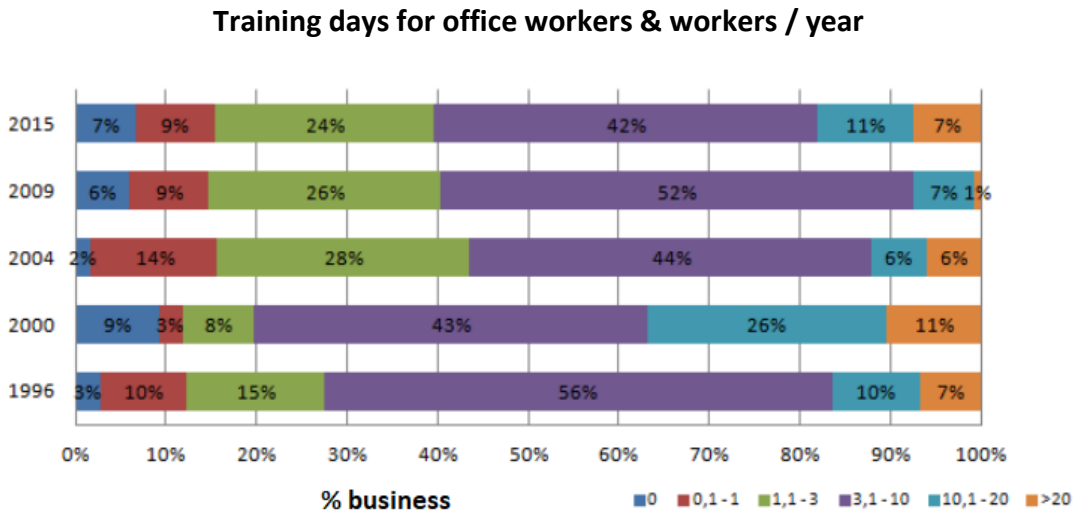


*Figure **Errore. Nel documento non esiste testo dello stile specificato.**-5: Training days per year, office workers and laborers*

Figure 2-4 show the number of training days per year received by various categories of workers. As is evident, its quantity varies training provided in each category. In particular, the scientific-administrative staff seems to receive it more education, with 9.3 average training days per year, while office workers with 8 days and executives with 7.54 days the year. These differences are attributed to different specialization and need information on new professional issues required in each working group.

For example, experienced executives may not participate so often in standardized training programs, both scientific and administrative staff to be systematically informed about

innovations and news issues arising in the relevant subject at a time. Please also mention here that in some cases, there are businesses that they responded to the thinking of employees who have been on a long-term basis program eg. graduate, which may increase the average of the days they have told us. The great demand for education that is characteristic of it is known of Greek society. This demand is also very strong in workers who view education as a means of upgrading them

qualifications and opportunities for professional development. Businesses they appear to be increasingly aware of the need to cover this which is also an important means of motivating them employees to improve their performance. Some will then be examined factors associated with staff development, such as growth careers and the evaluation of education.

6 Evolution of advanced manufacturing technologies in the country

Despite the steadily increasing globalization and growing competition, many companies have difficulties in the internationalization of their business. In this context the concept of offshoring becomes more and more popular. Offshoring means that production or business processes of an enterprise are outsourced to foreign countries and relocated in order to maintain competitiveness in global markets. Many of Greek Companies at mechatronic, are specialized in offshoring and offers its customers access to low-cost foreign development and production capacities in combination with Global project management and quality assurance as a service.

We are moving to a future where mechatronic systems are integrated with computers. Engineers with skills that help them to automate and simulate complex problems will be one of the top performers. The future engineers will need to understand how to communicate their technical knowhow with a computer, simulate it, run tests, extract the data and process it. Industries are now stepping up the game by performing computational tests before performing physical tests. Troubleshooting a component will soon no longer be manual. The idea is that rather than performing tasks and checks analytically and manually, engineers are expected to utilize computational powers to the maximum, figure out the solution and fix the issue while spending as little time as possible.

HVAC systems – deals with heat, ventilation and cooling systems. Thermal management is a popular field these days. News is that, software companies hire thermal management engineers to maintain their data centers. And these thermal engineers are expected to be fluent in coding and simulating HVAC systems.

The era of simulation is already here. Mechatronic engineers who can code, simulate and automate computationally have a ton of doors wide open before them, software companies these days are hiring thermal engineers to maintain their data centers. Production companies are hiring simulation engineers so that they can test their designs before finalizing them for manufacturing. Any engineering field you choose needs a simulation engineer.

6.1 Automation & Robotics Engineer

Robotic systems are already good at performing menial repetitive tasks that don't require the dexterity and attention to detail provided by a human worker. However, with constant advances in computing, energy storage and materials, robots are beginning to move from single arm welding and assembly robots to complex humanoid robots. A striking example of this are the Boston Dynamics robots. A robotics engineer is involved in every aspect of the design, development, testing and implementation of robotic systems. Robotics engineers are typically either mechatronic, electronics or mechatronic engineers. With the relentless march towards automation, the only jobs safe from automation are those within automation.

According to the latest available data, while in 2005 the Greek industry used two robots per 10,000 workers, their number stood at 17 robots per 10,000 employees in 2016. However, this is not realistic and is an overestimation, as according to Greek market, the number of industrial robots in our country is about 250. In Greece there is now a wide range of applications from both categories, as many robotic systems have been installed. Among other things, robotic systems are used in soldering work in the production of solar water heating systems, a sector where Greece is extremely competitive. Such cases are the use of robots in razors, aluminum products, etc.

The most automated company in Greece is BIC, which now employs about 40 robotics, and Calpak and FAGE will also have enough. Other domestic companies using robotics are: Athenian Brewery, ELVALCHALCOR, 3E, Aluminum of Greece, Chipita, Unilever, and General Mills Hellas etc.

6.2 High Technology Applications in The Primary Sector

The evolution of technology and automation in the primary sector over the last decade has changed the data. The application of innovative technologies to agricultural and livestock production enables safer, more economical, larger and, above all, sustainable production processes. The stagnation of our country in the implementation of these technologies, only as an opportunity, can be understood.

In Greece, a country with immense variability, conditions in the industry are changing at a rapid pace. Greek Universities in collaboration with the Research Centers of the country have already implemented experiments in apple, pear, peach and olive orchards, watermelons, vineyards and cotton and grain crops with excellent results.

The implementation of precision agriculture in cotton plantations began over the past 15 years in the region of Karditsa and other areas of Thessaly. For four consecutive years, the plots were mapped using GPS and using special sensors placed on the cotton harvester. The results are impressive since, with the application of precision farming techniques, savings of 18% of irrigation water, 35-50% of fertilizers and 62-70% of herbicides have been achieved.

The key areas of technologies related to smart agriculture are:

Management Information Systems:

Scheduled systems for collecting, processing, storing and disseminating data in the form required to carry out the operations and operations of an agricultural enterprise.

In 2014, Agrostis company introduced to the Greek market the first Farm Management Information System (FMIS) ,ifarma, is now a well-known trademark and is recognized as the best farm management software for agricultural holdings in Greece, used by some of the largest companies operating in the agricultural sector such as wineries, trading and export companies, cooperatives and producer organizations as well as many small and medium farming business and smallholder farmers.

Precision Agriculture:

Managing spatial and temporal change to improve economic performance combined with reduced inputs and environmental impacts. It includes Decision Support Systems (DSS) for the entire management of farms with the aim of optimizing input yields while preserving resources, characterized by the wide use of geo-localization systems (GPS, GNSS) , aerial photographs from UAVs, and the latest generation of ultrasonic images provided by Sentinel satellites, resulting in spatial variability maps of various variables that can be measured (e.g., performance soil characteristics / topography, organic matter content, humidity levels, nitrogen levels, etc.).

Agricultural Automation and Robotics:

The process of implementing robotics, automated control and artificial intelligence techniques at all levels of agricultural production, including farmbots and farmdrones.

7. SWOT analysis

In recent years, mechatronics is the fastest growing area of science, combines electrical engineering, electronics, mechanics and information technology in order to create complex machines that require multiple technologies to function. Due to the fact that mechatronics consists of so many different areas, employers require a many specialist working in the field. A mechatronics engineer deals with a lot of science fields, needs a lot of knowledge in computing, mechanical structures and controlling systems, and personal skills and capabilities. In this work, we aim to study the quality of education systems and its prospects in the field of Mechatronics.

The Study and Methods

This comparative SWOT analysis is a sub-study of a larger project of ERASMUS+ Knowledge Alliances project “New Metro” No 600984-EPP-1-2018-1-IT-EPPKA2-SSA investigating the state of the Mecanotronics academic discipline and its prospects in Greece.

In order to collect data for our study, we randomly select a number of participant from our country as follow:

- 33 young people/workers;
- 17 entrepreneurs or managers of enterprises;

The questionnaire is divided into four parts, which are:

- General questions
- Mechatronic Future Trends
- Mechatronics education
- Capabilities of mechatronic engineer and the most important competences that a "mechatronic" technician should have.

Table 1: Aggregate demograohic data of emmployers participants.

Gender		**Age**		Level of education (**Edu_1)**		Number of employees (**Empl)**		**I am… (**Position_1**)**	
Male	94,1 %	Mean	44,88	Bachelor's degree	23,5 %	Up to 50	47,1 %	A company owner	17,6 %
Female	5,9%	Minimum	29	Master's degree	47,1 %	51 – 100	17,6 %	A company manager	5,9%
		Maximum	62	Other	29,4 %	101 – 200	5,9%	A leading specialist (HR)	35,3 %
						501 – 1000	29,4 %	A leading specialist (Innovation manager)	35,3 %
								A leading specialist (other ……)	5,9%

Table 2: Aggregate demograohic data of workers participants.

Gender		**Age**		**Edu_1**		**Position**		**Experience**	
Male	85 %	Mean	28,09	Secondary school	9,1%	a student	21%	None	21 %
Female	15 %	Minimum	24	Bachelor's degree	76%	a young worker	70%	Less than a year	12 %
		Maximum	35	Master's degree	15%	unemployed	9,1%	1-5 years	49 %
								More than 5 years	18 %

The first part, general questions asked the demographic characteristics of the participants such as gender, age and the qualification of the participants. The demographic data are included in Table 1 and Table 2 for employers and workers respectively. The second part of the questionnaire was concerned with the most important technologies of the future. Participants asked to figure out the future of mechatronics in conjunction technological developments. In the next section, participants were asked about educational approach to mechatronics. Finally, participants were asked about the particular skills or capabilities, which should have a mechatronic engineer. More details about the questionnaire appears in Appendix A. To measure this construct, several Likert-scale items are added onto the questionnaire. Usually, Likert scaling uses a number of statements which appear to relate to a common theme; respondents then indicate their degree of agreement or disagreement on a response scale which could range from 1-5 or 1-7. The answer to each constituent question (often called an item) is scored, for example from 1 for Completely Disagree to 5 for Very Agree if the range of answers is in terms of five points. The individual scores are added up to form an overall score for each respondent.

Reliability Statistics (workers)

Cronbach's Alpha	N of Items
,941	80

(a)

Reliability Statistics (employers)

Cronbach's Alpha	N of Items
,950	58

(b)

*Figure **Errore. Nel documento non esiste testo dello stile specificato.**-6: Cronbach's alpha calculates the average of all possible reliability coefficients a) workers, b) employers.*

7.1 Reliability

First, we calculate the Cronbach's alpha coefficient to determine the internal consistency of the questionnaire. The Cronbach's alpha coefficient [0] is one of the most widely used measures of reliability in the scientific research of quantitative data types [0]. To qualify a questionnaire as reliable, we need a confidence level of 0.70 or higher. Initially, we applied the Cronbach's alpha in all dimensions of the questionnaire. The final Cronbach's alpha reliability coefficients parameters are averaged 0.649 to 0.950. Cronbach's alpha showed the questionnaire to reach acceptable reliability, $\alpha = 0.941$ in case of workers, and $\alpha = 0.950$ in case of employers. Most items appeared to be worthy of retention, resulting in a decrease in the alpha if deleted. The one exception to this was item 3 of part of mechatronics education, which would increase the alpha to $\alpha = 0.649$ (in case of mechatronics education dimension). As such, removal of this item should be considered. **Errore. L'origine riferimento non è stata trovata.** illustrates the Cronbach's alpha, calculated over the average of all possible reliability coefficients in case of workers (a), and in case of employers (b). It is observed that Cronbach's alpha has acceptable values [0].

<u>Findings and Results</u>

In this study, we will look at the Strengths, Weaknesses, Opportunities and Threats (SWOT) facing the educational system in the field of Mechatronics in Greece. SWOT is a general tool designed to be used in the preliminary stages of decision-making and as a precursor to strategic planning. We use it to analyze of Mechatronics Engineering educational system in our country in order to get an overall picture its present situation in relation to its community, and the industries its graduates will join.

The SWOT concept integrates the potential and weaknesses of the internal environment as well as the opportunities and threats related to the external environment of an educational system. In order to develop the educational strategy of Mechatronics engineering, as well as business strategy, a thorough analysis of the internal and external environment needs to be done. The different conditions affecting the external environment are (i) economic, (ii) social, (iii) technological and (iv) employment. The internal environment deals with the structure of the system and resources (human resources, administrative capacities, financial resources, facilities, know-how). An analysis of the internal environment helps identify the strengths and weaknesses of existing actions.

A SWOT analysis has been conducted by taking the following inputs into consideration:

Employer questionnaire, (10 questions -68 items, sent to 17 employers)

Young people questionnaire (9 questions -89 items, sent to 42 student/worker)

Strengths/ *Employers*

- High professional level of (Excellent academic backgrounds of) employers
- Attractive and modern technologies
- Uniform age profile for the employers.
- Mechatronics can be considered an independent discipline
- Appropriate and effective programs
- Cost to create a mechatronics study programs is not high
- Learning 4.0 is very useful in mechatronics curses
- High competence of employees in
    - Ability to design an automation process algorithm and prepare a technological task for machine design
    - Ability to work with specialised design and mechatronic machine control software
    - Ability to choose suitable materials, creating machine
    - Ability to create software for the programming of automated system control elements constructions
    - Ability to determine the operation precision of a mechatronic system
    - Ability to organize and manage the work of staff
    - Ability to choose in the designing process the coupling sizes and allowances to ensure quality long-term operation
- Employers willing to pay so as to promote the improvement of the professional competence of their staff trained Qualified staff

Strengths/ *Student - workers*

- Many bachelor and master's students/workers (satisfactory level of education)
- Human resources
- Easily finding a job
- having working experience
- mechatronics is a future –relevant subject

Weaknesses/ *Employers*

- Hard to find the right organization for relevant studies (focus on close field)
- Non appropriate and effective programs
- Teachers must be retrained
- Cost to create a mechatronics study programs is high
- More and more competences
- Low competence of employees in
    - Ability to estimate the costs of the machine in the design or creation process and set the term when the machine will pay for itself
- Requires a range of skills/capabilities from many areas
- Lack of high quality industry jobs in core sector
- Non traditional students
- Few women in the employer group.

Weaknesses/ Student - workers

- Challenge to find the right organization for studies
- Teacher must be retrained
- High cost of creation mechatronics study programs
- Lack of a range of skills/capabilities from many areas
- Large number of abilities
- Few female students/workers.

Opportunities /*Employers*

- Is a future-relevant subject
- Interdisciplinary and systematic thinking
- Opportunity to attract new students
- Learning 4.0 is very useful in mechatronics curses
- Change the process of learning (Learning 4.0)
- As new technology can be applied (Industrial, Microelectronics, Life Cycle Approaches, Advanced Design Systems, Collaborative robotics, Domestic robots)
- Provide to student more competences

- Less competitor
- Opportunity to build an undergraduate experience using the best practices from throughout the country
- Knowledge and technology transfer

Opportunities /Student /workers

- Attract new students
- Easley finding a job
- Less competitor
- It's a future job
- Work in a wide range of businesses.
- Continuing education for intellectual enrichment and for people of all ages
- Education will can help them to get special qualification and will can help them to work in our country and the other European countries

Threats

- It is not known
- Demand (Ability to problem solve, Key mathematics skills, Good Team Skills)
- Developments in technology may change this market beyond our ability to adapt.
- lack of specific knowledge and insufficiently trained staff can significantly reduce the interest in school / programs and lead to poor educational results

	Positive	Negative
nternal	Strenghts • High professional level of (Excellent academic backgrounds of) employers • Attractive and modern technologies • Uniform age profile for the employers. • Mechatronics can be considered an independent discipline • Cost to create a mechatronics study programs is not high • Learning 4.0 is very useful in mechatronics curses • Employers willing to pay so as to promote the improvement of the professional competence of their staff trained Qualified staff • Many bachelor and master's students/workers (satisfactory level of education) • Easily finding a job • Working experience • Mechatronics is a future –relevant subject	Weaknesses • Hard to find the right organization (focus on close field) • Non appropriate and effective programs • Teachers must be retrained • Cost to create a mechatronics study programs is high • Lack of a range of skills/capabilities from many areas (for employees) • Requires a range of skills/capabilities from many areas • Lack of high quality industry jobs in core sector • Non traditional students • Few women (employer or students/workers)
External	**Opportunities** • Is a future-relevant subject • Interdisciplinary and systematic thinking • Opportunity to attract new students • Learning 4.0 is very useful in mechatronics curses and change the process of learning • As new technology can be applied (Industrial, Microelectronics, Life Cycle Approaches, Advanced Design Systems, Collaborative robotics, Domestic robots) • Provide to student more competences • Less competitor • Opportunity to build an undergraduate experience using the best practices from throughout the country • Work in a wide range of businesses. • Continuing education for intellectual enrichment and for people of all ages • Education will can help young workers to get special qualification and will can help them to work in our country and the other European countries	Threats • Demand large scale of abilities (Ability to problem solve, Key mathematics skills, Good Team Skills, ...) results students to in Abandonm their studies • Less of interest due to range of diiferenent competenciew required from students /workers

As shown in the SWOT matrix example above, strengths and weaknesses are internal to the organization, while opportunities and threats are of external origin. Strengths and

opportunities are helpful to design country's strategy, and weaknesses and threats are harmful to this strategy.

Results of the SWOT analysis

The main strengths of mechatronics are its ability to deal with a wide range of technologies, including Industrial, Microelectronics, Life Cycle Approaches, Advanced Design Systems, Collaborative robotics, Domestic robots and expected to be future-relevant subject. This can lead to a new approach to train students, which allows to develop new skilled personnel in mechatronics area and to continuously adapt to new requirements. On the other hand, this proceeding can be supported by much (academic and industrial) experience regarding the process and elaborate tools.

Moreover, to face the main weaknesses and threats are indeed needed a structured, effective and directed educational framework to deal with high complexity and quickly react to new requirements, which can lead to a significant decrease in student retention.

Analysis of the Results

The main strengths of mechatronics are its ability to deal with a wide range of technologies, including Industrial, Microelectronics, Life Cycle Approaches, Advanced Design Systems, Collaborative robotics, Domestic robots and expected to be future-relevant subject. This can lead to a new approach to train students, which allows to develop new skilled personnel in mechatronics area and to continuously adapt to new requirements. On the other hand, this proceeding can be supported by much (academic and industrial) experience regarding the process and elaborate tools.

Moreover, to face the main weaknesses and threats are indeed needed a structured, effective and directed educational framework to deal with high complexity and quickly react to new requirements, which can lead to a significant decrease in student retention.

Analysis of the results of employer's responses

First, we analyze the results emerged from the survey of employers mostly represent the employers perspective in terms of trends and skills in mechatronics area.

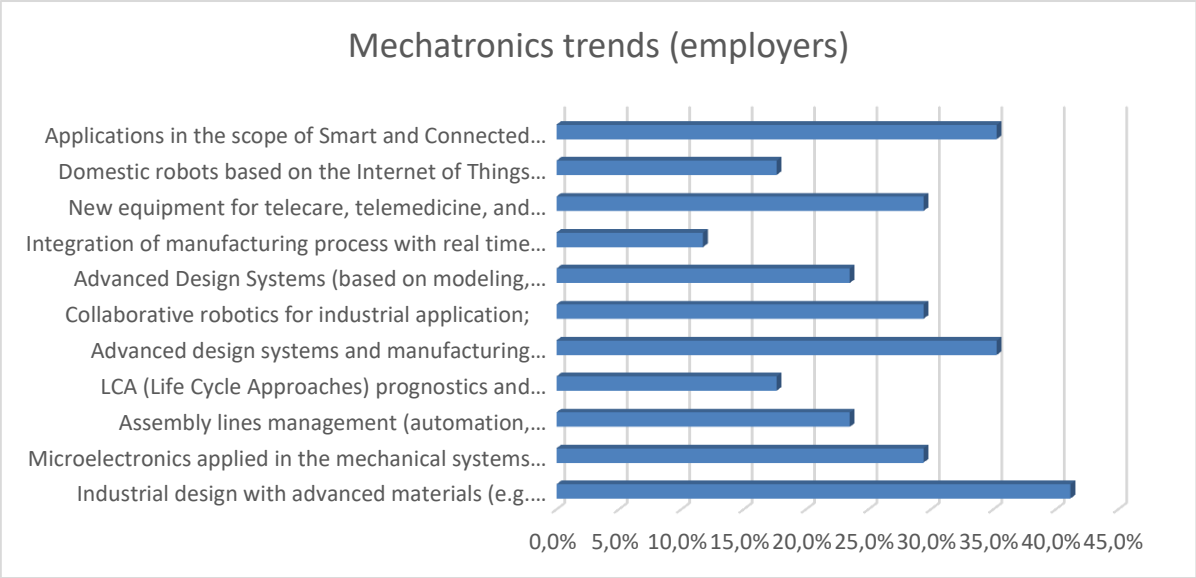


*Figure **Errore. Nel documento non esiste testo dello stile specificato.**-7: Most relevant trends in mechatronics area*

Greek employers thing a variety thecnologies as future trend and among them distinguish the following three:

a) Industrial design with advanced materials (e.g. biomaterials, metals, ceramics, polymers, powders (41,2%)
b) Advanced design systems and manufacturing integration (modelling, simulation, virtual testing, data management) (35,3%)
c) Applications in the scope of Smart and Connected Communities (35,3%)

In **Errore. L'origine riferimento non è stata trovata.** shown all the results.

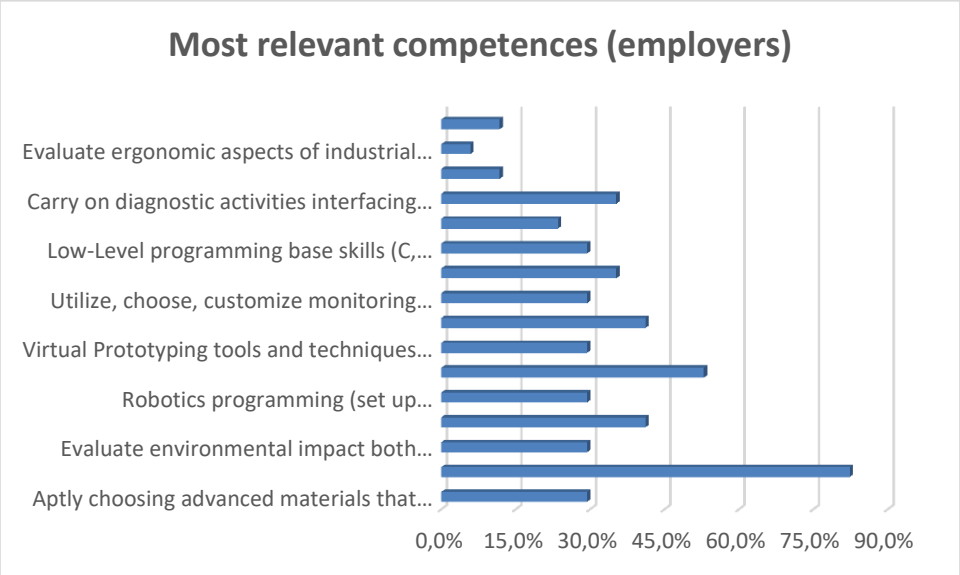


*Figure **Errore. Nel documento non esiste testo dello stile specificato.**-8: Most relevant competnce in mechatronics area*

According to Greek employers, the most five important competences in mechanotronics area is to:

a) Evaluate environmental impact both from product manufacturing and product whole life cycle (82,4%)

and the other four most relevant competence are:

b) Design virtual testing and validation using modelling and simulation tools (simulate mechatronic design concepts, use CAM software) (52, 9%)
c) Define pre-emptive maintenance protocols and early diagnostic maintenance protocols (maintain mechatronics equipment) (41,2%)
d) Carry on diagnostic activities interfacing machines/assembly lines and collecting data by LabView-like tools (resolve equipment malfunctions, maintain control systems for automated equipment, perform test run) (35,3%)
e) PLC programming (program a CNC controller) (35,3%)

In **Errore. L'origine riferimento non è stata trovata.** is depicted a set of competences and the importance rank according to employers. Among them, the following there is less important:

- Evaluate advanced logistics project aspects like cost/benefit ratio, safety, impact, threats, maintenance, etc.) (follow safety standards, new) (1,1%)
- Access a data base using SQL (record test data) (2,3%)
- Evaluate ergonomic aspects of industrial logistics (workloads, movements, time constraints, use of mobile devices, etc.) (2,3%)

Table 3: Summirized results about employers thing about mechanotronics.

Please, rate the following statements: circle a value: 0 – "I completely disagree"; 1 – "I somewhat disagree"; 2 I neither agree nor disagree; 3 I somewhat agree; to 4 – "I very agree")						
	N	Missing	Mean	Std. Deviation	Minimum	Maximum
Mechatronics can be considered an independent discipline	17	0	**2,47**	1,463	0	4
A challenge in mechatronics as a study discipline is to find the right organization and focus between courses in mechanical, electrical and computer engineering	17	0	**2,76**	1,393	0	4
Mechatronics study programs are appropriate and effective	17	0	1,71	1,047	0	3
Mechatronics is a future-relevant subject	17	0	**3,35**	0,996	0	4
Interdisciplinary and systematic thinking play an important role in mechatronics	17	0	**3,06**	0,966	0	4
To create a mechatronics study program, teachers must be retrained	17	0	**2,65**	1,320	0	4

Cost to create a mechatronics study programs is high	17	0	2,00	1,000	0	4
A mechatronics study program is an opportunity to attract new students	17	0	**2,94**	1,345	0	4
Learning 4.0 is very useful in mechatronics curses	17	0	**2,71**	0,920	0	4
A smart learning environment is essential for mechatronics courses	17	0	**2,47**	1,328	0	4

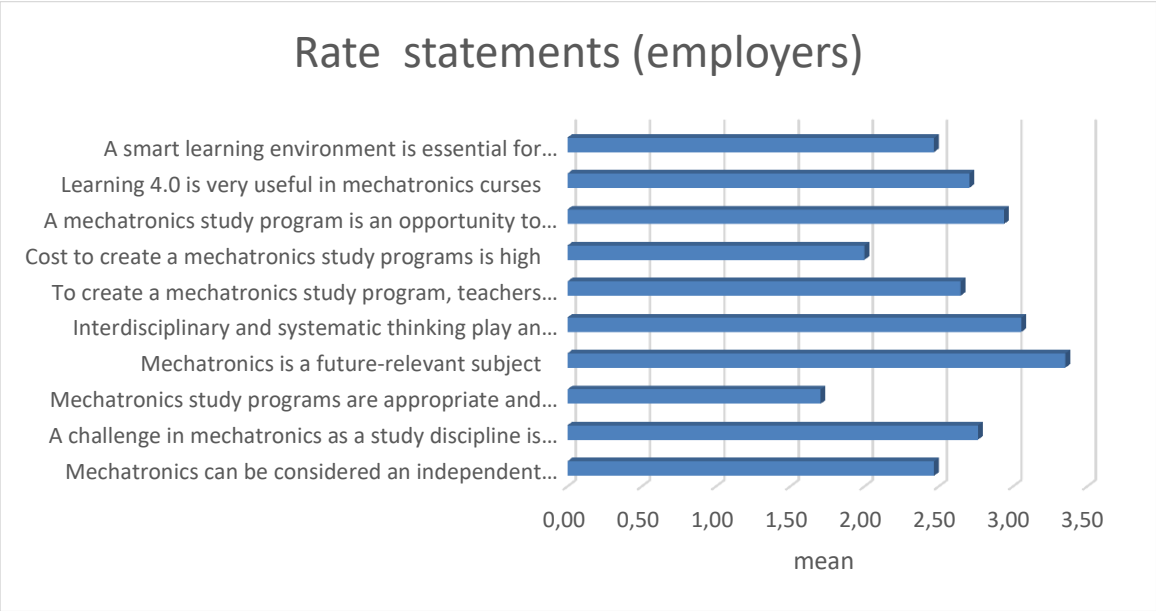


*Figure **Errore. Nel documento non esiste testo dello stile specificato.**-9: Employers rate the statements between 0 - "I completely disagree" to 4 – "I very agree". Here is the mean of answers.*

The table 3 summarize the results of employers' responses about mechatronics. It includes the minimum, maximum, mean, and standard deviation, based on the question's responses for employers' group. These observations have a minimum value equal to 0, and a maximum value equal to 4, while a neutral response assigns to 2 (that is a mean of Likert scale and express neither agree nor disagree). In **Errore. L'origine riferimento non è stata trovata.** shown **Errore. L'origine riferimento non è stata trovata.** The majority of employers agree with all statements and concern mechatronics as a future relevant subject, except the following:

a) the appropriate and effectiveness of study programs
b) and b) the high cost of creation mechatronics study programs. Almost all responders (mean 3,35) very agree that *mechatronics is a future-relevant subject* and they agree about the important role of interdisciplinary and systematic thinking in mechatronics.

Errore. L'origine riferimento non è stata trovata. also represents the three most dominant declaration about mechatronics, that are:

- Mechatronics is a future-relevant subject
- Interdisciplinary and systematic thinking play an important role in mechatronics
- A mechatronics study program is an opportunity to attract new students

Table 4: Summirized results about the skills corresponding to mechatronics workers.

Please assess the abilities corresponding to the competence of your employees - mechatronics engineers - (the actual situation), by circling the corresponding digit (0 – "not applicable", "1 – "no ability", 2 – "low level", 3 – "average level", 4 – "high level")						
	N Valid	Missing	Mean	Std. Deviation	Minimum	Maximum
Ability to design an automation process algorithm and prepare a technological task for machine design	17	0	**3,00**	1,323	0	4
Ability to work with specialised design and mechatronic machine control software	17	0	**3,24**	1,091	0	4
Ability to perform a visual assessment of the operation of mechatronic machines	17	0	**2,41**	1,176	0	4
Ability to design a mechatronic machine monitoring and visualisation system	17	0	**2,88**	1,269	0	4
Competence in the maintenance, diagnostics and repairs of automated machines	17	0	**2,41**	1,278	0	4
Ability to keep track of the number of spare parts of mechatronic machines and order these	17	0	**2,29**	1,160	0	4
Ability to design a production technology plan	17	0	**2,47**	1,231	0	4
Ability to assess the level of production automation	17	0	**2,82**	1,334	0	4
Ability to choose suitable materials, creating machine constructions	17	0	**3,29**	1,160	0	4
Ability to create software for the programming of automated system control elements	17	0	**3,24**	1,200	0	4
Ability to determine the operation precision of a mechatronic system	17	0	**3,00**	1,323	0	4
Ability to determine the lifetime of a mechatronic system	17	0	**2,53**	1,125	0	4
Ability to choose in the designing process the coupling sizes and allowances to ensure quality long-term operation of machines	17	0	**2,88**	1,166	0	4
Ability to assess the most economically advantageous technical solutions	17	0	**2,59**	1,176	0	4
Ability to estimate the costs of the machine in the design or creation process and set the term when the	17	0	**2,41**	1,121	0	4

machine will pay for itself						
Ability to plan work and organize its timely completion	17	0	**2,88**	1,111	0	4
Ability to organize and manage the work of staff	17	0	**2,47**	1,179	0	4
Ability to ensure the fulfilment of the environmental protection and health and safety law and regulation requirements	17	0	**2,65**	1,412	0	4
Ability to communicate in the official language and at least two foreign languages	17	0	**2,53**	1,281	0	4
Ability to study and understand the laws and regulations on the matters of machine safety	17	0	**2,59**	1,502	0	4
Competence in the International Organization for Standardization (ISO) quality safety and environmental protection systems	17	0	**2,76**	1,393	0	4

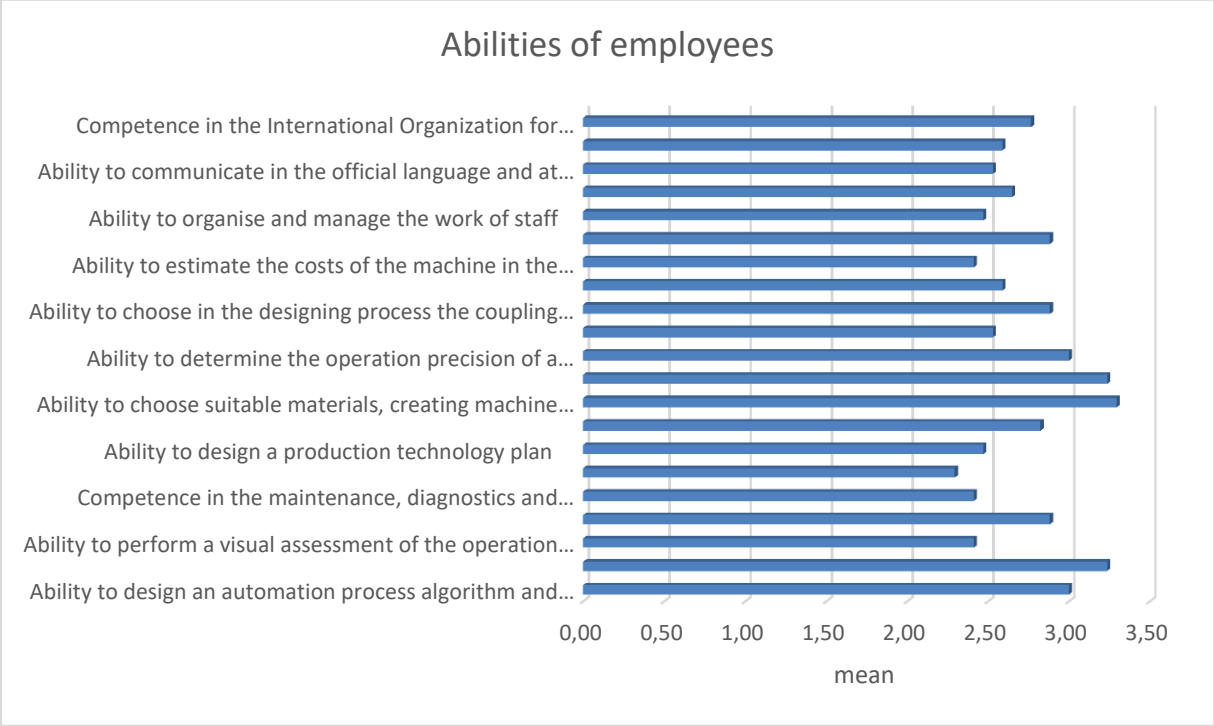


*Figure **Errore. Nel documento non esiste testo dello stile specificato.**-10: Most relevant competences for a mechatronics technician*

According to answers of employers, (**Errore. L'origine riferimento non è stata trovata.**), their emploees have a wide range of abilities in a satisfactory level. As depicted on the **Errore. L'origine riferimento non è stata trovata.**, five most relevant competences for a mechatronics workers are following:

1. Ability to choose suitable materials, creating machine constructions (3,29 at average, while 4 is the maximum)
2. Ability to work with specialized design and mechatronic machine control software (3,24)
3. Ability to create software for the programming of automated system control elements (3.24)
4. Ability to design an automation process algorithm and prepare a technological task for machine design (3.0)
5. Ability to determine the operation precision of a mechatronic system (3,0)

Analysis of the results of workers' responses

Here, we present the results emerged from students/workers questionnaire. The results were summarized and represent their opinion or expectation about mechatronics.

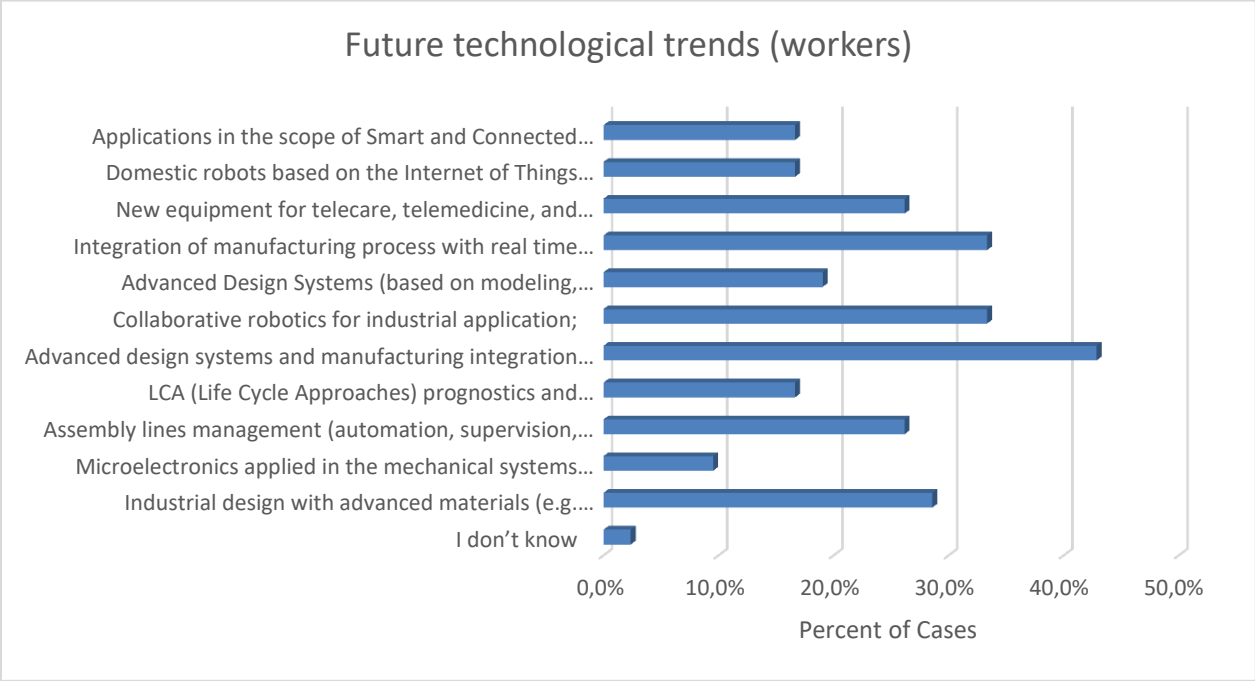
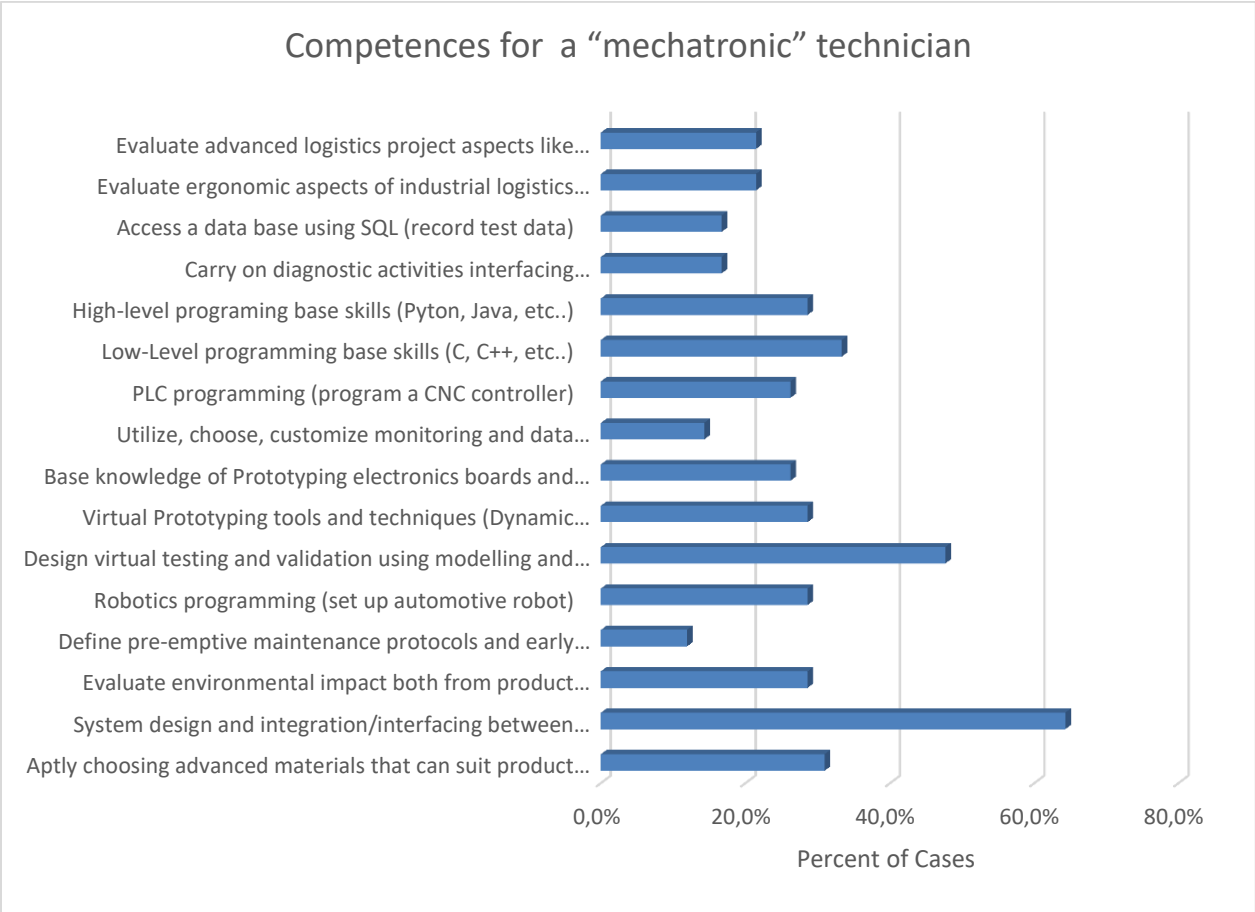


*Figure **Errore. Nel documento non esiste testo dello stile specificato.**-11: The most important technological areas for the next future.*

As obtained form the results and shown in **Errore. L'origine riferimento non è stata trovata.**, differences of opinion arise in terms of identification of what they do consider as important techological areas for the next future.The most (three) important of them are the following:

1. Advanced design systems and manufacturing integration (modelling, simulation, virtual testing, data management);(42,3%)
2. Collaborative robotics for industrial application;(33,3)
3. Integration of manufacturing process with real time available data (data management, machine learning, etc.); (33,3)



According to more than 60% of workers the major competence of a mechatronic technician is “*System design and integration/interfacing between electronic and mechanical components*”, and the second most competence is the knowledge of “testing and validation using modelling and simulation tools”. More specifically, the four most important competence are:

1. System design and integration/interfacing between electronic and mechanical components (assemble and test mechatronic units, set up machine controls, customise software, adjust engineering design) (64,3%)
2. Design virtual testing and validation using modelling and simulation tools (simulate mechatronic design concepts, use CAM software) (47,6%)
3. Low-Level programming base skills (C, C++, etc..)(33,3%)
4. Aptly choosing advanced materials that can suit product or process needs (31%)

Table 5: How students and workers imagine the future of mechatronics.

	Valid	Missing	Mean	Std. Deviation	Minimum	Maximum
Mechatronics can be considered an independent discipline	42	0	**2,14**	1,160	0	4
A challenge in mechatronics as a study discipline is to find the right organization and focus between courses in mechanical, electrical and computer engineering	42	0	**3,17**	0,730	1	4
Mechatronics study programs are appropriate and effective	42	0	1,55	0,916	0	4
Mechatronics is a future-relevant subject	42	0	**3,40**	0,701	2	4
Interdisciplinary and systematic thinking play an important role in mechatronics	42	0	**2,90**	0,692	1	4
To create a mechatronics study program, teachers must be retrained	42	0	**3,10**	0,878	1	4
Cost to create a mechatronics study programs is high	42	0	**2,40**	0,885	0	4
A mechatronics study program is an opportunity to attract new students	42	0	**3,19**	0,773	2	4
Learning 4.0 is very useful in mechatronics curses	42	0	**2,67**	0,902	1	4
A smart learning environment is essential for mechatronics courses	42	0	**3,10**	0,821	1	4

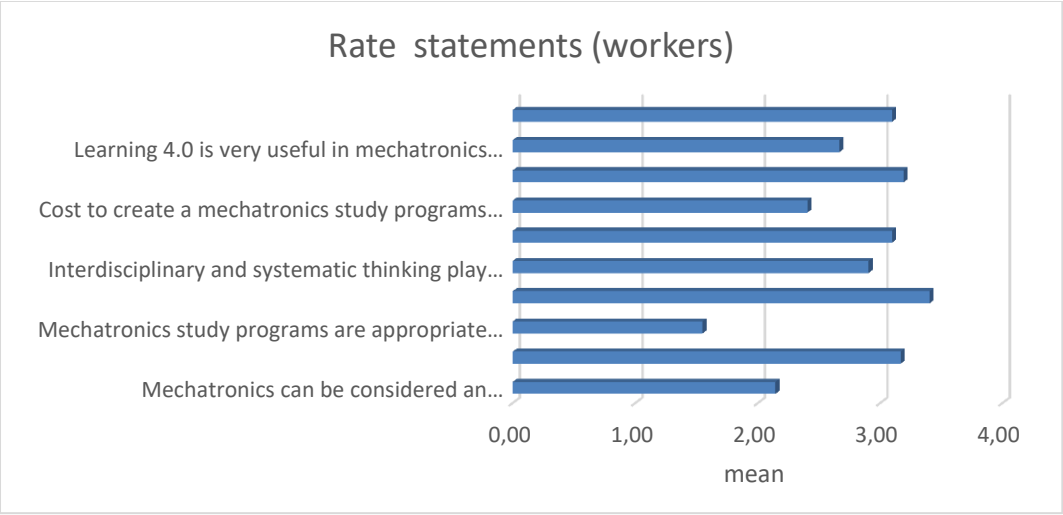


*Figure **Errore. Nel documento non esiste testo dello stile specificato.**-12: Statements about mechtronics*

The **Errore. L'origine riferimento non è stata trovata.** summarize the results of employers' responses about mechatronics. It includes the minimum, maximum, mean, and standard deviation, based on the workers' responses. These observations have a minimum value equal to 0, and a maximum value equal to 4, while a neutral response assigns to 2 (that is a mean of Likert scale and express neither agree nor disagree). In **Errore. L'origine riferimento non è stata trovata.** shown **Errore. L'origine riferimento non è stata trovata.** The majority of workers agree with all statements and concern mechatronics as a future relevant subject, except the "*appropriate and effectiveness of study programs*". It is noted that employers have the same view. Nevertheless, it is possible to make a reliable ascertainment, that mechatronics is a future-relevant subject.

Table 6: Actual level of student/workes competence

	Valid	Missing	Mean	Std. Deviation	Minimum	Maximum
Ability to design an automation process algorithm and prepare a technological task for machine design	42	0	**2,26**	1,191	0	4
Ability to work with specialised design and mechatronic machine control software	42	0	1,43	1,016	0	4
Ability to perform a visual assessment of the operation of mechatronic machines	42	0	1,64	1,032	0	4
Ability to design a mechatronic	42	0	1,60	1,061	0	4

machine monitoring and visualisation system						
Competence in the maintenance, diagnostics and repairs of automated machines	42	0	1,88	1,152	0	4
Ability to keep track of the number of spare parts of mechatronic machines and order these	42	0	1,98	1,220	0	4
Ability to design a production technology plan	42	0	1,90	1,165	0	4
Ability to assess the level of production automation	42	0	1,98	1,093	0	4
Ability to choose suitable materials, creating machine constructions	42	0	1,67	1,004	0	4
Ability to create software for the programming of automated system control elements	42	0	1,86	1,181	0	4
Ability to determine the operation precision of a mechatronic system	42	0	1,74	1,106	0	4
Ability to determine the lifetime of a mechatronic system	42	0	1,74	1,106	0	4
Ability to choose in the designing process the coupling sizes and allowances to ensure quality long-term operation of machines	42	0	1,62	1,011	0	4
Ability to assess the most economically advantageous technical solutions	42	0	**2,24**	1,185	0	4
Ability to estimate the costs of the machine in the design or creation process and set the term when the machine will pay for itself	42	0	1,83	1,102	0	4
Ability to plan work and organise its timely completion	42	0	**2,14**	1,095	0	4
Ability to organise and manage the work of staff	42	0	**2,48**	1,153	0	4
Ability to ensure the fulfilment of the environmental protection and health and safety law and regulation requirements	42	0	**2,26**	1,149	0	4

Ability to communicate in the official language and at least two foreign languages	42	0	**2,24**	0,958	0	4
Ability to study and understand the laws and regulations on the matters of machine safety	42	0	**2,48**	1,110	0	4
Competence in the International Organization for Standardisation (ISO) quality safety and environmental protection systems	42	0	**2,21**	1,159	0	4

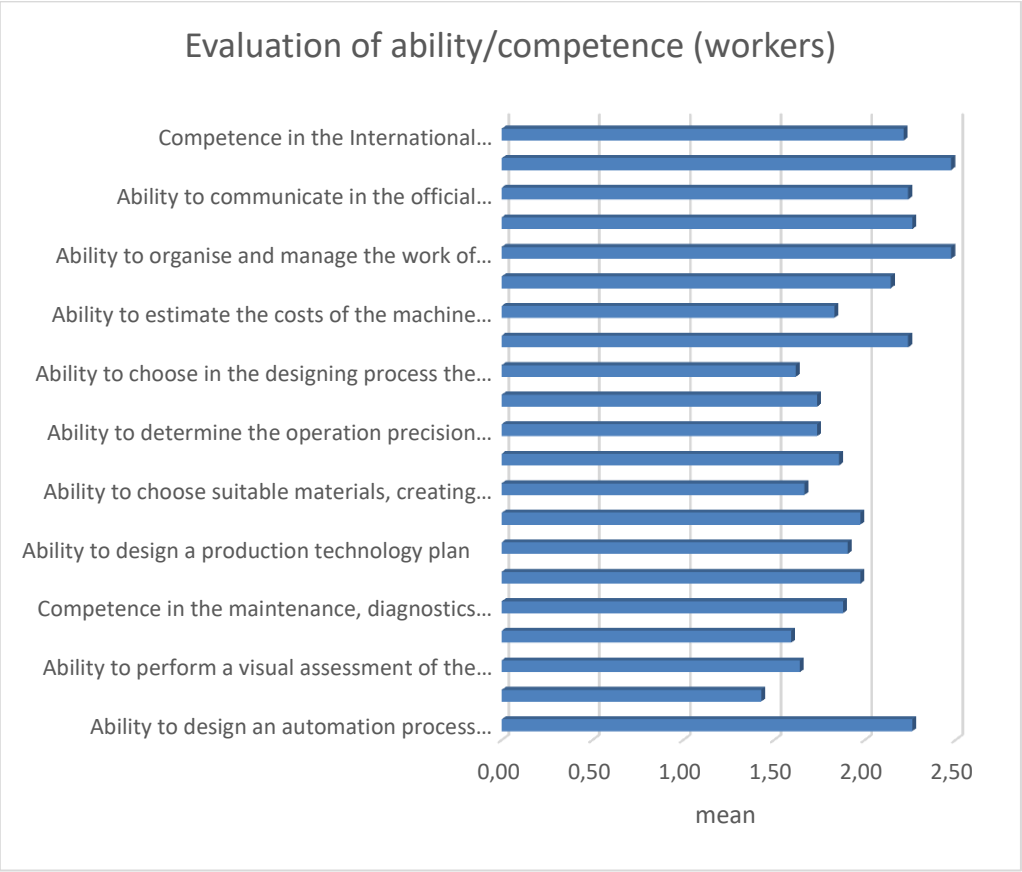


*Figure **Errore. Nel documento non esiste testo dello stile specificato.**-13: Workers evalute abilities/comprtences*

When workers asked for their actual abilities / competence, they appear rather restrained.The survey reveal that workers have only some abilities in satisfactory level (medium level), such as:

1. Ability to organise and manage the work of staff

2. Ability to study and understand the laws and regulations on the matters of machine safety

Table 7: The relative importance of workers' ability/competence

	Valid	Missing	Mean	Std. Deviation	Minimum	Maximum
Ability to design an automation process algorithm and prepare a technological task for machine design	42	0	**2,95**	1,125	0	4
Ability to work with specialised design and mechatronic machine control software	42	0	**2,57**	1,129	0	4
Ability to perform a visual assessment of the operation of mechatronic machines	42	0	**2,45**	1,041	0	4
Ability to design a mechatronic machine monitoring and visualisation system	42	0	**2,43**	1,039	0	4
Competence in the maintenance, diagnostics and repairs of automated machines	42	0	**2,52**	1,131	0	4
Ability to keep track of the number of spare parts of mechatronic machines and order these	42	0	**2,57**	0,991	0	4
Ability to design a production technology plan	42	0	**2,57**	1,016	0	4
Ability to assess the level of production automation	42	0	**2,76**	1,055	0	4
Ability to choose suitable materials, creating machine constructions	42	0	**2,50**	0,994	0	4
Ability to create software for the programming of automated system control elements	42	0	**2,71**	1,132	0	4
Ability to determine the operation precision of a mechatronic system	42	0	**2,60**	1,231	0	4
Ability to determine the lifetime of a mechatronic system	42	0	**2,38**	1,035	0	4
Ability to choose in the designing process the coupling sizes and allowances to ensure quality long-term operation of machines	42	0	**2,76**	1,144	0	4
Ability to assess the most economically advantageous technical solutions	42	0	**2,74**	0,989	1	4

Ability to estimate the costs of the machine in the design or creation process and set the term when the machine will pay for itself	42	0	**2,52**	1,087	0	4
Ability to plan work and organise its timely completion	42	0	**2,83**	1,010	0	4
Ability to organise and manage the work of staff	42	0	**2,64**	1,078	0	4
Ability to ensure the fulfilment of the environmental protection and health and safety law and regulation requirements	42	0	**2,81**	1,042	0	4
Ability to communicate in the official language and at least two foreign languages	42	0	**2,62**	1,103	0	4
Ability to study and understand the laws and regulations on the matters of machine safety	42	0	**2,86**	1,026	1	4
Competence in the International Organization for Standardisation (ISO) quality safety and environmental protection systems	42	0	**2,76**	1,100	0	4

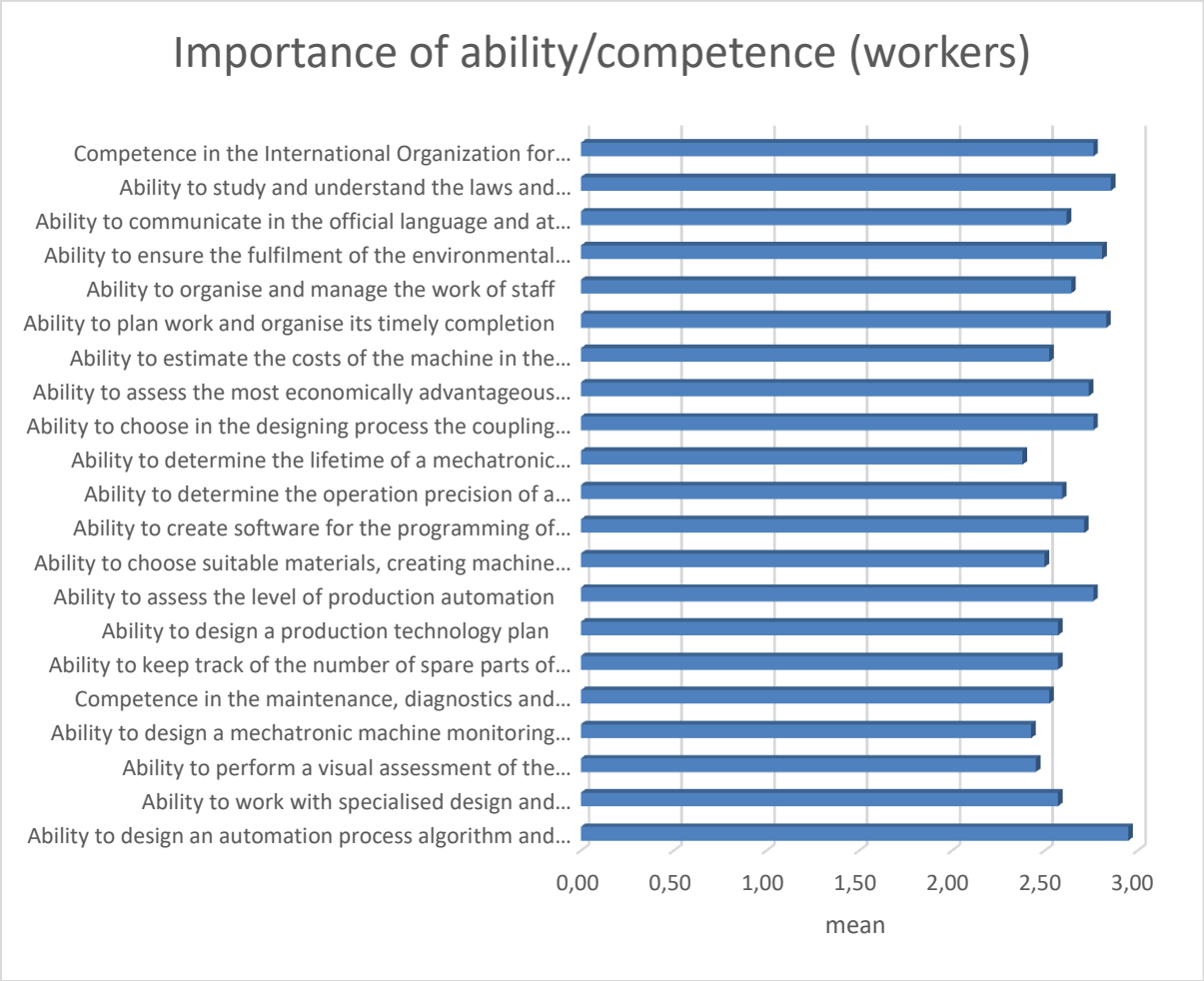


*Figure **Errore. Nel documento non esiste testo dello stile specificato.**-14: The relative importance of abilities/competence from workers perpective*

According to workers, (**Errore. L'origine riferimento non è stata trovata.**), a wide range of abilities is considering as important. l. As depicted in the **Errore. L'origine riferimento non è stata trovata.**, four most important competences for a mechatronics worker are following:

1. Ability to design an automation process algorithm and prepare a technological task for machine design
2. Ability to study and understand the laws and regulations on the matters of machine safety
3. Ability to plan work and organise its timely completion
4. Ability to ensure the fulfilment of the environmental protection and health and safety law and regulation requirements

Summary and Conclusion

The results emerged from the survey show that the participants (employer and workers) are very agree with the three eminent dimensions:

- Mechatronics is a future-relevant subject
- Mechatronics study programs are *not* appropriate and effective
- There is a gap between needed abilities and the actual

Students/workers are understanding the importance of a number of ability/competences relative to mechatronic technician, but they acknowledge their lack of those ability/competences. On the other hand, employers are willing to pay for an employee's further education.

In order to enable students and young workers to succeed in a rapidly advancing workplace, we suggest changes to educational system. This mean that key elements of the changes can be:

- Education: organize appropriate and effective programs
- Training and orientation according to needs: training young workers in mechatronics topics
- Knowledge development.

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