

# Machine Building and Mechatronics Field in The Industry 4 for 5 Regions in Europe

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**Abstract:** The article presents the needs for professional training of technicians and engineers in mechanical engineering and mechatronics was conducted in two areas of Bulgaria - Gabrovo and Plovdiv, Kavala, Greece, Pomorskie Region, Poland and Nis region, Serbia. These regions are very different, both in area and population and the most developed sectors of the economy. The survey was realized under an Erasmus+ KA2 programme which duration from 1.09.2020 up to 31.08.2022 with title Active Learning Community for Upskilling Technicians and Engineers. This works presents the basic data about the training proposals both for engineers and technicians. Last but not least illustrates the preferences of companies about the most suitable training method.

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## 1. Introduction

The article presents the basic results for the project Active Learning Community for Upskilling Technicians and Engineers (allCUTE) which funded within the ERASMUS+ Programme, KA2. It is established on a survey carried out among 161 companies in the sector of Machine Building and Mechatronics in order to recognize the requirements of technical and vocational education and training both for technicians and engineers. The survey realized at the same time at 5 different partner regions:

- Gabrovo region, Bulgaria;
- Plovdiv region, Bulgaria;
- Kavala, Greece;
- Pomorskie Region, Poland;
- Nis region, Serbia.

This survey is established according to the demands of Industry 4.0 imposed on today's technicians and engineers. Industry 4.0 includes four different modules i) Internet of Things, ii) Big Data and Analytics, iii) Engineering Simulation and iv) Additive Manufacturing. All these concepts have an important effect on machine building and mechatronics because have as a result to impose a whole redesign of processes and operations to fulfill those new developments. With intention to fit in the new data companies are aware that they are essential to invest in the training of their employees and always improve their competence and skills until to achieve their goals and meet the new demands of both manufacturing and customers.

The aims of this work are fivefold:

- to show the existing situation of the five aforementioned regions relevant with TVET provision to technicians and engineers employed in the area of Machine Building and Mechatronics;
- to detect the training needs of the companies in the relevant sector and improve the competence and performance of their technical and engineering staff;
- to recognize the teaching methodology preferred by the employers;
- to associate survey findings among partner regions;
- to give recommendations for the elaboration of the follow-up curriculum.

## 2. State in Partner Regions

### 2.1. Gabrovo region (Bulgaria)

The economy in the Region of Gabrovo is predominantly driven by the industrial sector. In 2018 the worth of the produced goods was nearly 1.25 billion € with over 1.6 billion € of which - produced by the production industry. The processing industry has a main share in the total economy of the region and constitutes about 60% of the total production, twice the average at a country level. Manufacturing of machinery, equipment and fabricated metal products has a leading role in the processing industry with the highest added value per employed person. Almost half of the income generated by the industry in the region comes from the above mentioned manufacturing. The Region of Gabrovo is also the central hub for the production of tools for the machine building industry with more than 20 companies operating



in this field. Economic center "Gabrovo-Sevlievo" having a strong industrial profile comprises the municipalities of Gabrovo and Sevlievo. It is rated among the 20 most important economic centers in Bulgaria. The industry of the region is predominantly export-oriented with more than 50% of all goods produced being exported. For the machine building industry products the export rate is even higher – about 66% [1].

### **2.2. Plovdiv region (Bulgaria)**

Plovdiv is the biggest industrial centre in Bulgaria. The total production is about € 8.75 billion in 2018, and that in industry is nearly B€GN 4.75 billion. The structure of the local economy is strongly dominated by manufacturing, which, according to NSI data, occupies 39.9% of it, which is 12% more than the second largest sector. Regarding to the produced production the share of the production is 55% while in relation to the incomes from the activity it is 36.3 %.

In the Plovdiv area is found Trakia Economic Zone (TEZ) - the major and most sustainable industrial zone not only in Bulgaria but also in Southeast Europe. It unites 6 industrial zones in the region of Plovdiv - "Maritsa", "Rakovski", "Kuklen", "Plovdiv", High-tech park "Innovations" and Agro park "Kaloyanovo". The area is over 10,700,000 square meters, half of which is already occupied. In the last twenty four years more than 3 billion euros have been invested in it. TEZ employs over 180 companies, half of which are foreign and is one of the most significant companies in Bulgaria - KCM 2000 AD [2].

### **2.3. Kavala region (Greece)**

The area of Kavala spreads in an area of approximately 2,111 km<sup>2</sup>, at the north part of Greece. Most of its people live in the city of Kavala (54,000) and has population of about 133,000. The region has an economy based heavily on the service sector (77%) while the secondary (12,5%) and primary (10,5%) contribute less to the local GDP. Tourism, agriculture, fishing and quarrying alongside an important public sector are the main activities of the residents. The area of Kavala affects the role of the gateway to the trans-European axes for the Aegean Sea and the center of international trade routes for the Balkans. It has also been accepted as an interregional-gateway with an international role through its airport, the Egnatia Motorway and the vertical axis from Bulgaria via the Exohi border station and its harbours [3].

### **2.4. Pomorskie region (Poland)**

Pomeranian region is one of the most dynamically developing regions in Poland. Many companies in this area playing significant part in the national economy. Pomeranian Voivodship is one of sixteen administrative regions of Poland. It is located in the northern part of the country, at the coast of the Baltic Sea. Based on the data of 2019, there were 26,574 commercial companies in the region, including 3,335 with foreign capital participation. Foreign firms make up 12.5% of all companies in the region [4-5]. The traditional industries of the area are related with the sea and include the petrochemical,

shipbuilding, electromechanical, construction, wood and furniture, tourism and food industries. While the food industry traditionally belongs to the leading sectors in the region's economy, it is of marginal importance. The agriculture, forestry, fishing and hunting sector supplied only 2,5% of the regional gross value added in 2017 [4]. Consequently, the priority sectors from the point of view of investment potential are electronics, logistics, maritime, modern business services, ICT, biotechnology and light chemistry, and food processing [6].

### **2.5. Niš region (Serbia)**

Based on the estimation of the Republic Bureau of Statistics in mid-2018, the number of inhabitants in the Regional Chamber of Commerce of Nisava, Pirot and Toplica administrative districts was 531,410, of which 48.25% live in the City of Nis, 10.23% in the City of Pirot, 8.95% in the municipality of Aleksinac, and 7.94% in the City of Prokuplje. Estimates were made on the basis of the 2011 Census of Population, Households and Dwellings and data on natural and mechanical population movements. In the structure of GDP of the RCC Nis, the most represented - services are 46.5%, which is below the national average, industry 40.3%, which is above the national average and agriculture, which participates with 8.1%, which is at the level republican average. Construction participates with 5.1%, which is slightly above the national average.

In the Sector of industry within CCIS RCC Nis consists of six associations: Association for metal and electrical industry, Association for construction industry, Association for chemical, rubber and non-metal industry, Association for textile, clothing, leather and footwear industry, Association for energy and mining and Association for pharmacy and medical activity, with 147 different business codes and 1,129 companies, which is 4.93% more than in the previous period (1,076). Operating income of all companies in the Industry Sector, according to the latest data for 2018, was 199,116,115,000 dinars, or 10.87% more than in the previous year (179,601,492,000 dinars). The foreign trade of the economy of CCIS RCC Nis reached ~ 2.7 billion EUR in 2019, with exports amounting to 1.591 billion EUR and imports of 1.116 billion EUR. The realized trade surplus at the level of RCC Nis amounted to 475 million EUR [7].

## **3. Results and discussion**

In order to identify the needs of additional qualification of technicians and engineers in the mechanical engineering and mechatronics sectors, a questionnaire with several sections was developed: size of the company, need for qualification of technicians, need for qualification of engineers, as well as those related to the training methodology. Based on the preliminary study, a set of topics for professional training of technicians and engineers was suggested. They cover sections of rapid development of technologies during the recent years, which suppose greater need for trained personnel.

For technicians:

- Pneumatics and electro-pneumatics

- Energy efficiency in pneumatic systems,
- Optimal use of compress air
- Vacuum and vacuum technology
- Hydraulic
- Electricity
- Electrical drives
- Automated manufacturing system
- CNC machines.

For engineers:

- Basic schemes in automated pneumatic systems, design of pneumatic and electrical pneumatic systems, diagnostics, maintenance, optimization
- Hydraulics, proportional hydraulics – design, diagnostics, maintenance
- Vacuum engineering and technology, vacuum systems, various capture methods in vacuum engineering
- Electrical engines
- Complex electrical drives
- Automated manufacturing systems - diagnostics, maintenance, troubleshooting
- Energy efficiency in pneumatic systems – measurement, maintenance, optimization.

The topics were discussed and supplemented by each partner; in addition each respondent had the capability to suggest other training topics.

The companies could select between 2 types of training:

- Active blended learning – the students get familiar with the learning material by using presentations online or through their smart phones, then they discuss the topics with the teacher in the classroom so as to clarify difficult issues and solve problems, after that they do their lab work;
- Traditional – the teacher delivers the learning material in the classroom and then the students do their lab work.

All questions allowed more than one answer (except for the methodology), which is why the total percentage of the answers is over 100%. Each partner selected the companies in their region to which the questionnaire was sent.

In relation with the survey of the needs for vocational training, contacts have been made with 1002 companies from the five areas in the field of mechanical engineering and mechatronics. 161 companies or 16.07% of all companies answered. The relatively low response rate can be easily explained owing to the survey period - November and December 2020 - the strongest second wave of the COVID-19 in Europe and worldwide. Table 2 shows the statistics about the size and the number of each company regarding to the five regions while figure 1 illustrates the total data according to the type of companies according to number of employees.

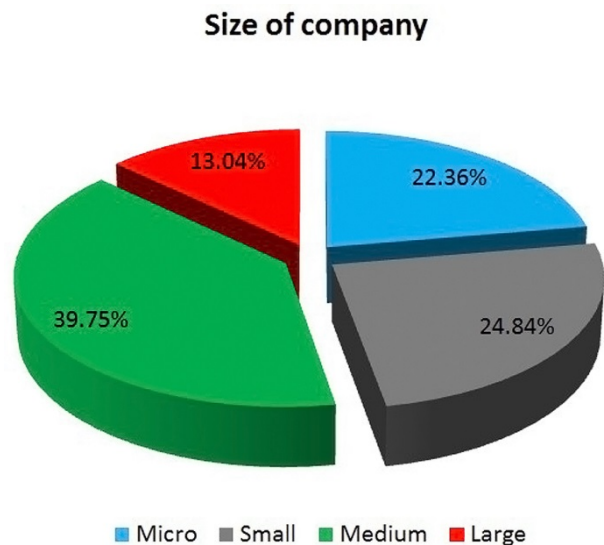
The highest percentage of respondents is among medium-sized enterprises - 64 (39.75%). This is broadly consistent with the structure of enterprises in this sector. The small enterprises follow - 40 (24.84%) and micro enterprises - 36 (22.36%). The percentage of large enterprises is 13.04% (21 companies) with the largest

number of technicians and engineers is also significant. Their percentage is much higher than their share of the total number of enterprises.

Regarding to the large enterprises the biggest numbers that have responded are from Plovdiv (Bulgaria) region because there a number of large enterprises from this sector in the Thrace Economic Zone, followed by Gabrovo (Bulgaria). Another interesting information is the fact that no large companies from Greece replied, this owing to the characteristic of the Kavala region which characterized by micro and small enterprises.

**Table 1.** The size of the participated companies

Size of company	Region				
	Gabrovo	Plovdiv	Kavala	Nis	Pomorskie
Micro	5	-	8	14	9
Small	8	5	7	8	12
Medium	11	15	16	7	15
Large	6	10	-	1	4
Total	30	30	31	30	40



**Fig. 1.** Category of companies along with number of employees

### 3.1. Training needs of technicians

When studying the needs of technicians in different regions, we have obtained different results. The most wished training in Gabrovo Region is "Operating CNC machines" (22 companies), which has been selected by all types of companies. For Plovdiv Region the most desired trainings for technicians are "Electricity" (20 companies) and "Operating automated production system" (20 companies). For Kavala Region the most preferred training is the "Pneumatics and electro-pneumatics" with 48% of the companies have selected this training. The most chosen training for technicians in Pomeranian region is "Operating automated production system" (19 companies) and in Nis Region "Operating CNC machines" and 40% of companies expressed their interests in this type of training.

The summarized statistics shows that there is no training option, which has not been selected at least by one company.

The top three most preferred trainings for all regions are:

- Operating CNC machines, selected by 62 companies;
- Operating automated production systems, selected by 58 companies;
- Pneumatics and electro-pneumatics selected by 57 companies.

According to the size of companies, their preferences are distributed as follows:

- Micro enterprises: Operating CNC machines is the most chosen in 3 of the 5 regions namely Gabrovo, Pomeranian Region and Nis. In Greece the most preferred is Pneumatics and electro-pneumatics.
- Small companies: Pneumatics and electro-pneumatics in Kavala and Nisa, Operating CNC machine“ in Gabrovo, Electricity and Hydraulics“ in Plovdiv; Operating automated production systems in Gdansk.
- Medium-sized companies: Pneumatics and electro-pneumatics is the most preferred training in two regions Nis and Plovdiv; Operating automated production systems in 2 areas, Gdansk and Kavala; Electrical engines, complex Electrical drives - in Gabrovo; Operating CNC machines in Nis, Electricity in Plovdiv
- Large companies: Operating CNC machines in Gabrovo, Gdansk and Nis region, Operating automated production systems in Plovdiv.

### 3.2. Training needs of engineers

Similar are the result and for the needs of engineers in the five regions. The most preferred training for engineers:

- in Gabrovo area is Programming and maintenance of CNC machines; 25 of the companies selected this training ;
- in Plovdiv area is Automated manufacturing systems; 23 of the companies selecting this training;
- in Kavala region is Automated manufacturing systems with 52% of the companies choosing this training;
- in Gdansk is Automated manufacturing systems - diagnostics, maintenance, troubleshooting.
- in Nis are Hydraulics, proportional Hydraulics and Automated manufacturing systems with 23%.

The summarized information shows that there is no training option, which has not been chosen at least by one company.

The top three most preferred trainings for all regions are:

- Automated manufacturing systems by 64 companies;
- Basic schemes in automated pneumatic systems, design of pneumatic and electrical pneumatic systems, diagnostics, maintenance, optimization by 47 companies;
- Hydraulics, proportional Hydraulics by 42 companies.

The least chosen training is: Vacuum engineering and technology, vacuum systems, various capture methods in vacuum engineering by 20 companies.

Consistent with the type of companies, their preferences are spread as follows:

- Micro enterprises: Automated manufacturing systems – diagnostics, maintenance, troubleshooting - in Kavala and Gdansk. Programming and maintenance of CNC machines in Gabrovo. Energy efficiency in pneumatic systems with 25% in Kavala, Hydraulics“, proportional Hydraulics in Nis with 21%.
- Small companies: Automated manufacturing systems – diagnostics, maintenance, troubleshooting with 80 % in Plovdiv and in Nis and Gdansk with lower percentage. Programming and maintenance of CNC machines with the impressive 88.88% in Gabrovo; Hydraulics, proportional Hydraulics“ with 80% in Plovdiv. Basic schemes in automated pneumatic systems in Kavala with 71%
- Middle-sized companies: Automated manufacturing systems – diagnostics, maintenance, troubleshooting – in Kavala region with 81% and also in Plovdiv and Gdansk with a little lower percentage, Programming and maintenance of CNC machines with 81.81% in Gabrovo, Basic schemes in automated pneumatic systems selected by 67% from companies in Plovdiv, Hydraulics, proportional Hydraulics which is chosen by 43% of companies in Nis.
- Large companies: Automated manufacturing systems – diagnostics, maintenance, troubleshooting was chosen from every large companies in Nis, by 83.83% companies in Gabrovo and by 90% companies in Plovdiv. Programming and maintenance of CNC machines is selected by 83.83% in Gabrovo. Basic schemes in automated pneumatic systems with 90% in Plovdiv and Gdansk regions.

Based on the preliminary study, a certain set of topics for professional training of technicians and engineers was proposed. They cover areas of rapid development of technologies during the recent years, which suppose greater need for trained personnel.

### 3.3. Training methodology

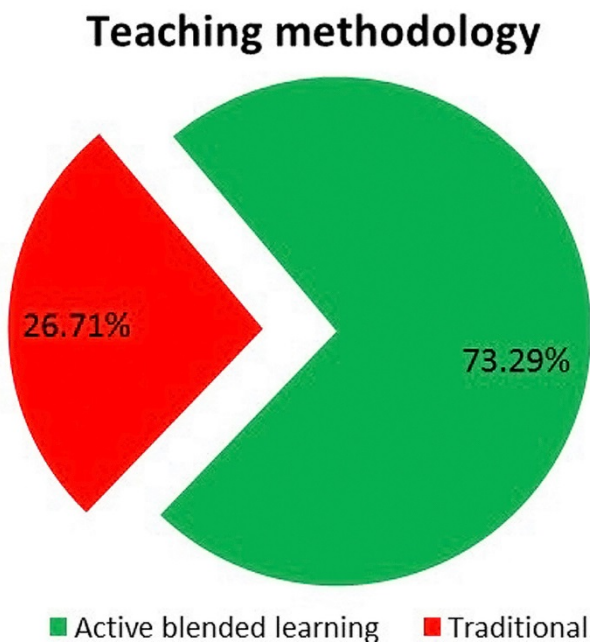
The companies had the option to select between 2 training methods:

- Active blended learning where the learners get familiar with the learning content by using presentations online or through their smart phones, then they discuss the topics with the teacher in the classroom so as to clarify difficult issues and solve problems, after that they do their lab work;
- Traditional which means the teacher delivers the learning content in the classroom and then the learners do their lab work.

In all regions, all types of companies have predominantly supported Active blended learning, with percentages ranging between 65% (in Kavala) and 83% in Gabrovo and Nis (Table 2). Support among all types of companies is between 57% and 100%, with the lowest percentage among small companies (57%) in Kavala area. Figure 2 shows the total results and according these more than 73% from companies prefers the active blended learning.

**Table 2.** The preferred teaching method for each of the investigated region.

Type	Region				
	Gabrovo	Plovdiv	Kavala	Nis	Pomorskie
Active blended learning	25	24	20	25	24
Traditional	5	6	11	5	16



**Fig. 2.** The collective results about the training method.

#### 4. Conclusions and future work

The survey reveals that there are many differences between each of the five investigated regions. There is a dissimilar degree of industry development and more specifically of mechanical engineering and mechatronics in the different regions. The least developed in this respect is Kavala (Greece), while these industries occupy the highest portion of economy in the areas of Gabrovo and Plovdiv (Bulgaria). There are also well-developed production sectors both in the Pomeranian and Nis areas. Nevertheless of those differences, the partnership region covered has the potential to boost the sector of Machine Building and Mechatronics. Furthermore, there are universities that train students for mechanical engineering and mechatronics industries in all surveyed regions.

According to our estimations, it can be said that there is an adequate number of potential users of the project outputs in all regions. It is estimated that the total number of engineers and technicians is about 52,000. The training suggestions for engineers and technicians have been chosen by different number of companies in the survey in the different areas, which is directly dependent on the production of the companies that participated in the survey. To the basis of the survey findings, the following courses are highly recommended to be developed:

Courses for technicians:

- Operating automated production system
- Pneumatics and electro-pneumatics
- Electrical Drives
- Operating CNC Machines
- Hydraulics
- Electricity

Courses for engineers:

- Automated manufacturing systems
- Basic schemes in automated pneumatic systems
- Hydraulics, proportional hydraulics
- Electrical engines, complex electrical drives
- Energy efficiency in pneumatic systems

The most preferred teaching methodology is active blended learning. Therefore, the courses should be based on active learning techniques. The analysis of the training needs of the employed technicians and engineers in the area of Machine Building and Mechatronics shows that there is a demand of upskilling those target groups and there are enough potential users of such training. Hence, the courses to be developed will be useful for the companies in the above industrial sector. Companies are alert that they should invest in the training of those employees so as to uninterruptedly enhance their competences with the purpose of achieve excellence and meet the new demands of both manufacturing and customers in the era of Industry 4.0.

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