

Active Learning Community for Upskilling Technicians and Engineers

Kalliopi Ntolou¹, Despoina Parasyri², Jacob Fantidis^{1*},
Panagiotis Kogias¹ and Eleni Papadopoulou¹

¹International Hellenic University, Faculty of Science, Department of Physics, Saint Loucas,
65404 Kavala, Greece

²Kavala Chamber of Commerce, 50a Omonoias Str., 65302 Kavala, Greece

*E-mail of corresponding author: fantidis@physics.ihu.gr

Abstract: Based on the data of a recent survey in European Union more than 40% of EU employees experienced a recent change in the technologies they use at work. According to the experts new technologies and structural modification in many areas and professions will provide a higher dependence on cognitive and interpersonal skills in future works. Active Learning Community for Upskilling Technicians and Engineers is a project, developed under Erasmus+ programme, KA2 and lasting from 1.09.2020 to 31.08.2022. It offers an alternative solution to address these challenges and needs by developing an active learning platform for engineering and technical staff in the sector of Machine Building and Mechatronics. This article also presents the results from the 2 lesson which realized in Kavala, Greece.

Received 10 May 2022

Accepted 30 June 2022

Published 22 July 2022

Keywords: engineering, technical staff, Erasmus+, allCUTE, Industry 4.0.

1. Introduction

Without doubt Industry 4.0 is totally transforming the manufacturing sector in European Union imposing its principle of digitalization of industrial processes. Consequently, the new cyber-physical production systems have a high impact on the labour force, especially on technicians and engineers.

Today technicians and engineers should analyze big data, simulate production lines, coordinate robots and diagnose/repair complex automated systems. Unfortunately the real situation is that employees are not ready to face the above new realities since they lack the “right” knowledge/skills demanded by the new industrial environment. According to the data from the @Cedefop’s European skills and jobs (ESJ) survey 43% of adult employees have recently experienced changes in technology they use at work and 47% have seen changes in their working methods. About 1 in 5 considers it very likely that several of their skills will become outdated in the next years [1].

The 2019 Talent Shortage Survey shows an average of 54% shortage of skills in EU: Greece - 77% (engineering and technical skillset shortage is respectively top 2 and 1); Bulgaria - 62% (3 and 5); Poland -70% (5 and 1), and Serbia – 78% (Serbian Employers Union Survey). Therefore, although on different scale, skills deficit of employees appear a European issue, which severely affects the manufacturing sector [2].

Continuous technical and vocational education and training (CTVET) systems are not well developed in the partner countries and mainly targets unemployed, low-qualified workers, etc. It rarely addresses continuous TVET of employees, in particular technicians and engineers and does not respond to the immediate needs of that target group – dedicated time on the clock to learn, high level of support, online learning platforms with open resources, mobile and active learning. VET trainers are mainly skilled in technical areas rather than pedagogy, so teacher-centred approaches are predominantly used.

Taking into account the above needs, their relevance at European level and emergency at regional level, as well as the high demand of flexible continuous TVET on behalf of companies within the partner regions, a consortium of 4 universities, 4 Chambers of Commerce and Industry and a VET provider from Bulgaria, Greece, Poland and Serbia was established so as to develop an Active Learning Community for Upskilling Technicians and Engineers (allCUTE) in the sector of Machine Building and Mechatronics [3-11].

2. Methodology

2.1. Project partnership

Coordinator of the project is the Technical University of Gabrovo, Bulgaria while the other partners is the Cluster Trakia Economic Zone in Bulgaria, the Gabrovo Chamber of Commerce and Industry also from Bulgaria, the International Hellenic University in Greece, the Kavala Chamber of Commerce also from the Greece, the Gdansk University of Technology and the Regional Chamber of Commerce both from the Gdansk area in Poland and last but not least the University of Nis and the Serbian Chamber of Commerce from Serbia (Figure1).



© The Author(s). Published by CIEES Association Press. This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 4.0 Generic License.



Fig. 1. A consortium scheme of the allCUTE project

2.2. TVET needs of technicians and engineers in the sector of Machine Building and Mechatronics

According to the new data a worker of the Industry is necessary to have four skills: Adaptive skills (embracing technology, mindset change), Technical skills (automation systems, energy optimization and sustainability, systems engineering), Transversal skills (innovative thinking, decision making, communication and collaboration, respect for the environment, etc.) and Technological skills (smart engineering, smart infrastructure, data analysis, cyber security, integrated platforms).

In order to identify the TVET needs of technicians and engineers in the sector of Machine Building and Mechatronics a report is written within the ERASMUS+ Programme, KA2, project allCUTE. It is based on a survey carried out among 161 companies in the sector of Machine Building and Mechatronics so as to identify the needs of technical and vocational education and training of their technicians and engineers. It covers 5 partner regions:

- Gabrovo region, Bulgaria;
- Plovdiv region, Bulgaria;
- East Macedonia and Thrace region, Greece;
- Pomorskie Region, Poland;
- Nis region, Serbia.

The Report is developed in the context of the demands of Industry 4.0 imposed on today's technicians and engineers (Figure 2). The 4 key elements of Industry 4.0: Internet of Things, Big Data and Analytics, Engineering Simulation and Additive Manufacturing have a significant impact on machine building and mechatronics since they require complete redesign of processes and operations to accommodate those new advancements. Therefore, those industries need forward-thinking technical and engineering staff who can embrace these digital tools and technologies so as to design, repair and maintain the increasingly smart manufacturing facilities. To do that, companies are aware that they should invest in the training of those employees so as to continuously improve their competence and skills in

order to achieve excellence and meet the new demands of both manufacturing and customers.

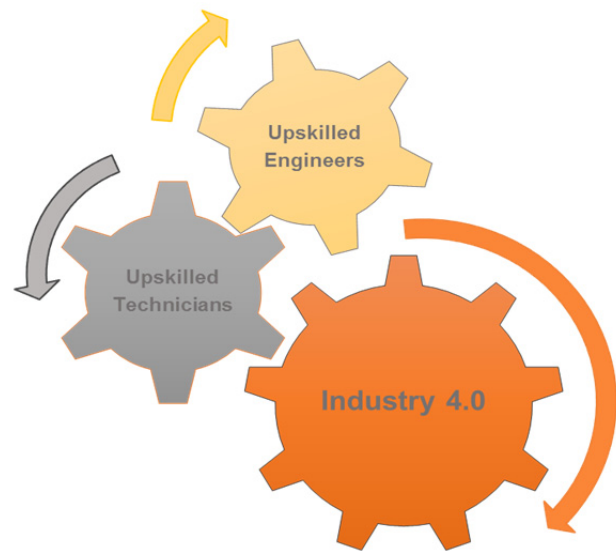


Fig. 2. The central idea of the allCUTE project

This Report aims to:

- present the current situation of the partner regions in relation to TVET provision to technicians and engineers employed in the sector of Machine Building and Mechatronics;
- identify the training needs of the companies in the respective sector by partner region so that they can improve the competence and performance of their technical and engineering staff;
- identify the teaching methodology preferred by the employers;
- compare survey findings across partner regions;
- give recommendations for the elaboration of the follow-up curriculum.

2.3. Target Groups

The target groups of the project can be divided in 2 groups: i) the direct target groups which includes both the Technicians in the sector of Machine Building and Mechatronics and the Engineers in the sector of Machine Building and Mechatronics and the indirect target groups in which belongs the VET trainers, the Companies in the

sector of Machine Building and Mechatronics and the VET providers, including universities and Chambers. The benefits will be multiply for each group and more specific:

Technicians and engineers

- Upskilled STEM, in particular in particular technology and engineering skills
- Improved generic skills such as analytical/critical thinking, problem-solving, communication
- Easier access to TVET learning platforms (Internet-based and mobile) that best match their learning styles
- Easier access to educational resources to be used for upskilling
- Ability to quickly and adequately respond to Industry 4.0 fast technological changes in the respective industrial sector
- Opportunity for securing their positions within the company and future career development
- Opportunity for building a “culture of learnability” in the long run

VET trainers

- Improved teaching competence by mastering active learning techniques and strategically using ICT
- Ability to better motivate learners
- Easier access to TVET resources

Companies in the sector

- Better awareness of the specific TVET needs of their engineer
- Upskilled technicians and engineers ready to respond to the fast technological changes in the sector
- Opportunity to adequately meet the demands of Industry 4.0 in the long run
- Potential of higher economic growth in the long run

VET providers, including universities and Chambers

- Better awareness of the specific TVET needs of the engineering and technical staff employed in the sector
- Access to TVET learning platforms that best match learning styles of end-users
- Access to educational resources to be used for upskilling
- Opportunity to train their VET teachers on active learning tools
- Opportunity to provide TVET to companies that matches the demands of Industry 4.0 and the specific learning needs of their employees.

3. Results and discussion

To study 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, need to increase the so-called soft skills, as well as those related to the training methodology.

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.

After analyzing the survey results, the following 8 courses for technicians have been identified as a priority of employers in the respective industrial sector [12]:

1. Electricity
2. Electrical Drives
3. Pneumatics and electro-pneumatics
4. Hydraulics
5. Vacuum and vacuum technology
6. Optimal use of compressed air
7. Operating CNC Machines
8. Operating automated production system

While the following 6 courses for engineers have been identified as a priority of employers in the respective industrial sector [12]:

1. Basic schemes in automated pneumatic systems
2. Energy efficiency in pneumatic systems
3. Hydraulics, proportional hydraulics
4. Electrical engines and complex electrical drives
5. Automated manufacturing systems
6. Quality assurance, quality control and testing.

Table 1 shows the topic of each of the courses for technicians while table 2 illustrates the topics for the 6 lessons for the engineers. Each lesson will be available in five languages namely English, Serbian, Bulgarian, Greek and Poland.

The selected topics related to key competencies (soft skills) were:

- Team work (active listening and understanding different viewpoints, ability to respect and trust others, self-evaluation and self-criticism, endurance when working under pressure)
- Communication skills – (ability to communicate and build trust, effective receiving and sending of information)
- Problem-solving (analytical and critical thinking; taking personal responsibility, identifying problems, decision making and response, risk assessment)
- Adaptability and flexibility (accepting and understanding different environment and new and different ideas, compliance with rules, established principles and relationships, ability to accept criticism, positive thinking)
- Work ethic
- Creativity
- Growth mindset (motivation to reach higher levels of achievement by continuously learning new skills in order to move with a changing market).

The companies could choose between 2 types of training:

- Active blended learning – the students get familiar with the learning content by using PP 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 content 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%.

Table 1. The topics of the each lesson for the training of technicians.

Course 1 - Electricity T1 Introduction to Electricity T2 Electrical Resistance T3 Voltage T4 Electrical Current T5 Inductors T6 Capacitors T7 Oscilloscope T8 Three phase circuit T9 Thermographic testing of electrical equipment T10 Electrical Safety	efficiency T2 Structure of the pneumatic system T3 Some properties of compressed air T4 Basic problems with compressed air T5 Basic causes of energy losses in the manufacturing plant T6 Potential for savings in pneumatic systems in air production T7 Potential for savings in pneumatic systems in air preparation T8 Potential savings in pneumatic systems for the distribution and supply of air T9 Potential savings in compressed air systems at consumers T10. Energy efficiency in vacuum systems T11 Monitoring and optimization
Course 2 - Electrical Drives T1 Basic concepts of electrical engineering T2 Rectifiers and filters T3 Power converters T4 Constant and variable-frequency control T5 D.C. motors T6 Induction motors T7 Stepper motors T8 Electrical drives T9 Variable-frequency drives (VFD) T10 Servo drives	Course 7 - Operating CNC Machines T1 CNC machines, introduction, and principles of work T2 Concepts of CNC machine control T3 CNC system programming methods T4 Work Safety T5 Technological preparation for CNC machining T6 G-code structure and syntax T7 Tools calibration and path optimization T8 Introduction to CAM software T9 Program management and execution (Example for lathe training) T10 Program management and execution (Example for milling training) T11 Independent work with supervision and help
Course 3 - Pneumatics and Electro-pneumatics T1 Theoretical basics T2 Compressed air production T3 Preparation of compressed air T4 Pneumatic actuators T5 Sensors for pneumatic cylinders T6 Pneumatic valves T7 Elements for regulating the flow, timers, logic elements T8 Pneumatic and mechanical controlled circuits T9 Electro-pneumatic control T10 Sequence solution methods. Repeat pattern sequence. Non-repeat pattern sequence T11 PLC Pneumatic Circuit Control T12 Pneumatics applications in continuous production processes	Course 8 - Operating Automated Production System T1 Basic concepts and issues in the field of automation of manufacturing processes and production systems T2 Operation and maintenance of automated production systems T3 Flexible automation means and integration of technological processes; automation of machining processes T4 Computer-aided technological preparation of production T5 Trends and developments in the automation of production systems
Course 4 - Hydraulics T1 Introduction to hydraulic drives T2 Basic parameters of hydraulic drives T3 Pressure valves T4 Directional control valves T5 Cylinders T6 Hydraulic control devices T7 Speed control elements T8 Variable flow control valve T9 Fluids for hydro-systems T10 Basic hydro-schemes for propulsion and control	Table 2. The topics of the each lesson for the training of engineers.
Course 5 - Vacuum and Vacuum Technology T1 Vacuum theoretical basics. Expressions and units. Measurement methods. Vacuum quality T2 Compressed air vacuum production T3 Compressed air-driven ejector pumps T4 Vacuum systems for material handling T5 Suction cups (vacuum pads) T6 Vacuum sensors and switches T7 Vacuum valves – types and operation T8 Vacuum, pneumatic and electro-pneumatic controlled circuits T9 Vacuum suction control circuits T10 Integrated applications with pneumatic drives T11 Electronic vacuum regulators T12 Use of vacuum in continuous production processes - freeze drying, filtration, distillation, test equipment, etc.	Course 1 - Basic Schemes in Automated Pneumatic Systems T1 Basic steps to air preparation equipment calculation and selection T2 Basic steps to build compressed air piping systems T3 Design complete pneumatic control systems T4 Design of pneumatic and electro-pneumatic control circuits for feeder modules T5 Design of pneumatic and electro-pneumatic control circuits with timers T6 Design of pneumatic and electro-pneumatic control circuits with counters T7 Design of pneumatic and electro-pneumatic control circuits with pressure programmable relay T8 Design of pneumatic and electro-pneumatic control circuits with logic elements T9 Design of pneumatic and electro-pneumatic control circuits with vacuum equipment T10 Pneumatic circuit design using PLC T11 Pneumatic valve actuators and positioners T12 Electronic pressure regulators. Principle of operation, parameters and applications
Course 6 - Optimal Use of Compressed Air T1 Energy efficiency - essence, purpose and benefits of energy	Course 2 - Energy Efficiency in Pneumatic Systems T1 Reduce pressure drop in the distribution system T2 Turn off the power during downtime of pneumatic systems T3 Involve the OEM in designing more energy efficient machines and compressor air systems T4 Add sensors to high pressure and consumption machines and processes T5 Reduce leakage

T6 Optimize compressed air systems
 T7 Incorporate air saving circuits where appropriate
 T8 Energy savings starts at the top of organizations and relies on all-inclusive teams

Course 3 - Hydraulics, Proportional Hydraulics

T1 Elements of hydraulics circuits (pumps, motors and valves)
 T2 Basic circuits with hydraulic cylinder and motor
 T3 Control of speed of a motor with the use of throttle valve
 T4 Volumetric control of motor speed
 T5 Circuits with flow regulators
 T6 Pump regulators
 T7 Proportional valves
 T8 Electronic control of proportional valves
 T9 Introduction to systems with servo valves

Course 4 - Electrical Engines, Complex Electrical Drives

T1 Definition, functions and features of an electromechanical systems and drives
 T2 Electromechanical system components and their functions
 T3 Electrical machines and material technology. Classification of electrical machines
 T4 Properties and characteristics of motors and generators
 T5 Structures of electromechanical systems used in industry
 T6 Electromechanical system development, evolutions and trends
 T7 Power units used in electric and hybrid vehicles
 T8 Electromechanical systems with piezoelectric machines
 T9 Electromechanical energy storage devices
 T10 Electromechanical drives developed with nanotechnology
 T11 Basic definition and terms: physical model, mathematical model, simulation, design

Course 5 - Automated Manufacturing Systems

T1 Sensors
 T2 Actuators
 T3 Numbers and Data
 T4 Boolean Logic Design
 T5 Control System Analysis and Design
 T6 Advanced Control Systems
 T7 Programmable Logic Controllers - PLC-s

Course 6 - Quality Assurance, Quality Control and Testing

T1 Introduction to Quality Control and the Quality Assurance
 T2 The Concept of Quality Control in Manufacturing
 T3 Statistical process control (SPC)
 T4 Introduction to industrial experimentation
 T5 Guidelines for designing industrial experiments
 T6 Factorial designs
 T7 Analysis of case studies – modelling and analysis of a given industrial process/system – working examples
 T8 Independent work with supervision and help
 T9 Introduction in FMEA method, definition weight factors and recognition level of risk
 T10 Sheet metal forming
 T11 Bulk metal forming

Each partner selected the companies in their region to which the questionnaire was sent.

The topics were discussed and supplemented by all partners. All respondents had the opportunity to suggest other training topics. Totally the project has 5 main outcomes:

- **Survey** on the skills deficit of technical and engineering staff in the sector of Machine Building and Mechatronics.

- **Teacher's ToolKit** on Active and Problem-based Learning. It is an attempt to tackle the transversal skills' gap.

- **Curriculum** for upskilling technicians and engineers in the sector of Machine Building and Mechatronics.

- **14 course materials** (PPT presentations, industry-related problems and additional internet resources) as open educational resources. It is an attempt to tackle the talent and transversal skills' gap.

- **Problem-based platform** – industry-relevant problems; a discussion forum for tutor and peer-to-peer support; assessment area for assessing the gained knowledge. It is an attempt to tackle the transversal and digital skills' gap.

3.1. Lessons and results

In International Hellenic University have realized two lessons one for 15 technicians and another for 15 engineers. The relevant lesson for the first group was the "Electricity" while for the engineer participants were the "Energy Efficiency in Pneumatic Systems".

Results from the survey among trainees:

Table 3 illustrates the questionnaire which given to the participants after they finished the training. For each of the question 5 was the highest mark and 1 was the lowest. The questionnaire includes 16 questions which are divided in 4 groups namely this is usefulness, course materials and teaching methodology, ALC platform and overall evaluation.

Table 3. The results according to the learners answers for each of the lessons

I. USEFULNESS

Q1. The training was useful for my better performance at work.
 Q2. The training helped me improve my technical skills.
 Q3. The training helped me improve my generic skills (teamwork, critical thinking, problem solving, etc.)
 Q4. Now I have a better chance for career development.
 Q5. Now I have easier access to vocational training.

II. COURSE MATERIALS AND TEACHING METHODOLOGY

Q6. The course materials are well-structured and attractive.
 Q7. The course materials are user-friendly.
 Q8. The training is practice-oriented.
 Q9. The teaching methodology is active and encourages creativity.
 Q10. The use of ICT is well incorporated into the learning process.

III. ACL PLATFORM

Q11. The Platform is user-friendly.
 Q12. The Platform is well-structured and attractive.
 Q13. The Platform facilitated my learning process.

IV. OVERALL EVALUATION

Q14. My expectations were met.
 Q15. I enjoyed the course.
 Q16. I would join another course in the future if offered.

According to the results in the field of **usefulness** the marks fluctuate from 3.87 up to 4.60 for the lessons "Electricity" and from 3.60 up to 4.53 for the lesson "Energy efficiency in pneumatic systems" so is evidence that the learners believe that the training is necessary (Figure 3). In this field for both lessons the highest score occur in the question "Q5. Now I have easier access to vocational training." Which shows that owing to this project the technicians believe that is more close to the

vocational training. In the same filed the minimum is achieved for the Q3 for the lessons “Electricity and for the question Q4, for the lesson “Energy efficiency in pneumatic systems”. These results indicates that the engineers want vocational training however have some uncertainties about how this training is enough in order to find a better job.

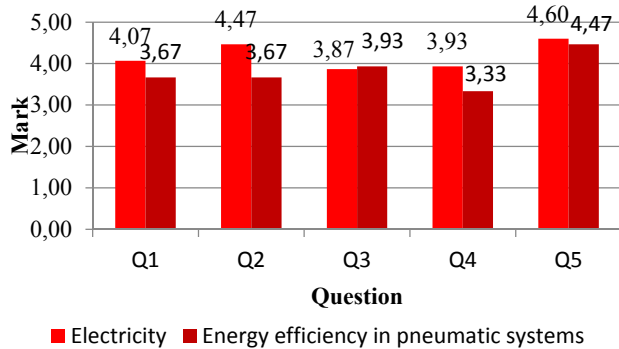


Fig. 3. The marks for the 5 questions relevant with the USEFULNESS of the lessons

Similar is the results and for the next session **materials and teaching methodology** with marks between to 3.93 up to 4.8 for the lesson “Electricity” and 3.60 up to 4.53 for the lesson “Energy efficiency in pneumatic systems” with the maximum rank in the question Q8 “The training is practice-oriented” for the first lesson and for the question Q10 “The training is practice-oriented” which proves that the technicians want practical and not theoretical training teaching and (Figure 4).

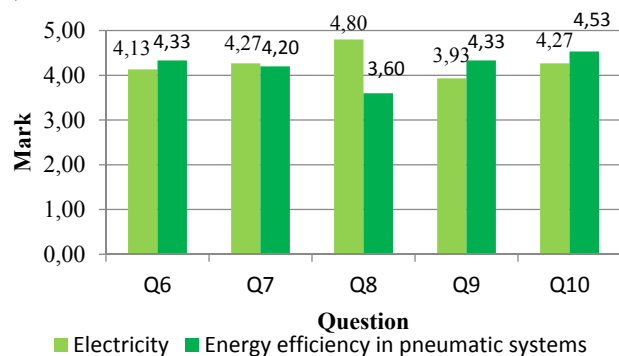


Fig. 4. The marks for the 5 questions relevant with the II. COURSE MATERIALS AND TEACHING METHODOLOGY

The next field ALC platform has slight lower grades because during the training only some lessons were uploading in the platform. According to the figure 5 the highest mark in this part was in the question Q11 “The Platform is user-friendly” while the lowest occur for the questions Q13 “The Platform facilitated my learning process”.

Figure 6 shows that in the most important section this **of the overall evaluation** the results prove that learners evaluate positive the course and want participate again in similar projects with the maximum score for the question Q15. I enjoyed the course and Q16.

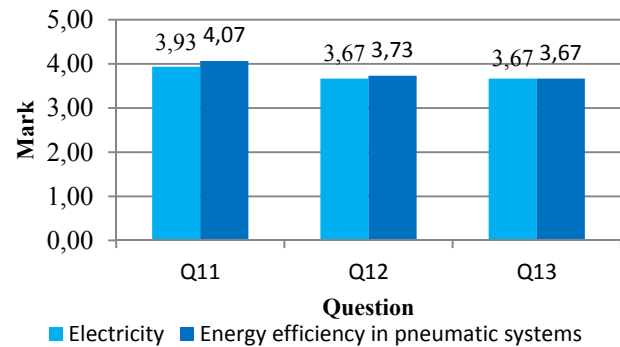


Fig. 5. The marks for the 5 questions relevant with the III. ACL PLATFORM

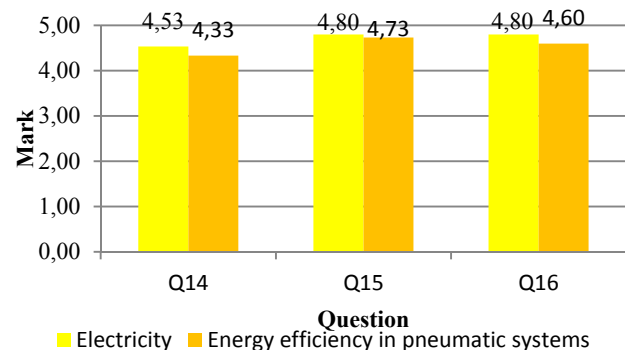


Fig. 6. The marks for the 5 questions relevant with the IV. OVERAL EVALUATION

Results from the survey among companies:

Table 4 shows the relevant results for the companies, again 5 is the highest mark and 1 is the lowest. From the results is obvious that the companies understand the essentiality of the vocational training for the technicians.

Table 4. The results according to the companies answers for the lesson

QUESTIONS	Electricity	Energy efficiency in pneumatic systems
	Mark	Mark
1. Do you intend to send more engineers and technicians to attend technical courses for upskilling?	4.33	4.73
2. Do you think further vocational training help your engineering and technical staff to perform better?	4.93	5
3. Do you feel your company would be more competitive if your engineers and technicians regularly attend vocational training for upskilling?	4.87	5

From the results we can say that both the technicians and the companies have very positive attitude relevant with the training especially when this is practice-oriented. The results of the test indicate that the learners have understood the lesson. Last but not least the interest of the technicians for the thermal camera, point at they are open to change and to adapt to new technologies.

4. Conclusions and future work

Significant interest has been shown in improving technicians' and engineers' soft skills such as problem-solving, communication skills, etc. The most preferred teaching methodology is active blended learning. Therefore, the courses should be based on active learning techniques so that they can build not only technical skills but also improve soft skills demanded by employers.

The analysis of the training needs of the employed technicians and engineers in the sector 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 material to be developed will be useful for the companies in the above industrial sector.

Companies are aware that they should invest in the training of those employees so as to continuously improve their competences in order to achieve excellence and meet the new demands of both manufacturing and customers in the era of Industry 4.0.

Based on the data from the two lessons derives some common conclusions. First of all, both engineers and technicians estimate that the training can help them and evaluate very positive this training program. Also according to the answer is obviously that both choose practical lessons compared with this with theoretical aspect. Last but not least a really high percentage of workers desire to participate again in such types of project while all the companies believes that further vocational training help both engineering and technical

staff to perform better and hence companies would be more competitive.

Acknowledgements

Special thanks to the associates of the project for the harmonious collaboration during the allCUTE project. This work was supported by the Erasmus+ program (PROJECT NUMBER: 2020-1-BG01-KA202-079042).

References

- [1] Cedefop (2015), Skills, qualifications and jobs in the EU: the making of a perfect match? Available on line <https://www.cedefop.europa.eu/en/publications/3072> DOI: 10.2801/606129, TI-RF-15-003-EN-N, ISBN: 978-92-896-1945-5, 23/11/2015
- [2] Manpowergroup, Talent shortage survey 2020, Closing the Skills Gap: What Workers Want, Available on line https://go.manpowergroup.com/hubfs/MPG_WhatWorkersWant_2020.pdf,
- [3] Technical University of Gabrovo, <https://www.tugab.bg/>
- [4] Gdansk University of Technology, <https://pg.edu.pl/>
- [5] International Hellenic University, <https://www.ihu.gr/>
- [6] University of Nis, <https://www.ni.ac.rs/>.
- [7] Cluster Trakia Economic Zone, <https://tez.bg/>.
- [8] Gabrovo Chamber of Commerce and Industry, <https://chamber-gabrovo.com/>
- [9] Regional Chamber of Commerce, <https://rigp.pl/>
- [10] Kavala Chamber of Commerce, www.kcci.gr
- [11] Serbian Chamber of Commerce, <https://nis.pks.rs/>
- [12] <https://allcute.eu/en/publications>