Active Learning Community for Upskilling Technicians and Engineers

Kalliopi Ntolou\textsuperscript{1}, Despoina Parasyri\textsuperscript{2}, Jacob Fantidis\textsuperscript{*}, Panagiotis Kogias\textsuperscript{1} and Eleni Papadopoulou\textsuperscript{1}

\textsuperscript{1}International Hellenic University, Faculty of Science, Department of Physics, Saint Loucas, 65404 Kavala, Greece

\textsuperscript{2}Kavala 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.

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 About 1 in 5 considers it very likely that several of their skills will become outdated in the next years [1].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).
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.

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 | Course 2 - Electrical Drives | Course 3 - Pneumatics and Electro-pneumatics | Course 4 - Hydraulics | Course 5 - Vacuum and Vacuum Technology | Course 6 - Optimal Use of Compressed Air |
|------------------------|------------------------------|-----------------------------------------------|----------------------|----------------------------------------|------------------------------------------|
| T1 Introduction to Electricity | T1 Basic concepts of electrical engineering | T1 Theoretical basics | T1 Introduction to hydraulic drives | T1 Vacuum theoretical basics | T1 Energy efficiency - essence, purpose and benefits of energy |
| T2 Electrical Resistance | T2 Rectifiers and filters | T2 Compressed air production | T2 Basic parameters of hydraulic drives | T2 Compressed air vacuum production | T2 Structure of the pneumatic system |
| T3 Voltage | T3 Power converters | T3 Preparation of compressed air | T3 Pressure valves | T3 Compressed air driven ejector pumps | T3 Some properties of compressed air |
| T4 Electrical Current | T4 Constant and variable-frequency control | T4 Pneumatic actuators | T4 Directional control valves | T4 Vacuum systems for material handling | T4 Basic problems with compressed air |
| T5 Inductors | T5 Sensors for pneumatic cylinders | T5 Pneumatic valves | T5 Cylinders | T5 Suction cups (vacuum pads) | T5 Basic causes of energy losses in the manufacturing plant |
| T6 Capacitors | T6 Time regulating the flow, timers, logic elements | T6 Hydraulic control devices | T6 Induction motors | T6 Vacuum sensors and switches | T6 Potential for savings in pneumatic systems in air production |
| T7 Oscilloscope | T7 Speed control elements | T7 Speed control elements | T7 Stepper motors | T7 Vacuum valves – types and operation | T7 Potential for savings in pneumatic systems in air preparation |
| T8 Three phase circuit | T8 Variable flow control valve | T8 Variable flow control valve | T8 Electrical drives | T8 Vacuum, pneumatic and electro-pneumatic controlled circuits | T8 Potential savings in pneumatic systems for the distribution and supply of air |
| T9 Thermographic testing of electrical equipment | T9 Variable-frequency drives (VFD) | T9 Variable-frequency drives (VFD) | T9 Electrical drives | T9 Vacuum suction control circuits | T9 Potential savings in compressed air systems at consumers |
| T10 Servo drives | | | | T10 PLC Pneumatic Circuit Control | T10 Energy efficiency in vacuum systems |
| | | | | T10 Sequence solution methods. Repeat pattern sequence. Non-repeat pattern sequence | T10 Monitoring and optimization |

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 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

Table 2. The topics of the each lesson for the training of engineers.

| Course 1 - Basic Schemes in Automated Pneumatic Systems | Course 2 - Energy Efficiency in Pneumatic Systems |
|--------------------------------------------------------|--------------------------------------------------|
| T1 Basic steps to air preparation equipment calculation and selection | T1 Reduce pressure drop in the distribution system |
| T2 Basic steps to build compressed air piping systems | T2 Turn off the power during downtime of pneumatic systems |
| T3 Design complete pneumatic control systems | T3 Involve the OEM in designing more energy efficient machines and compressor air systems |
| T4 Design of pneumatic and electro-pneumatic control circuits for feeder modules | T4 Add sensors to high pressure and consumption machines and processes |
| T5 Design of pneumatic and electro-pneumatic control circuits with timers | T5 Reduce leakage |
| T6 Design of pneumatic and electro-pneumatic control circuits with counters | |
Outcomes:

The project has 5 main partners. All respondents had the opportunity to suggest which the questionnaire was sent.

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. ALC 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 field 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.

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).

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.

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 |
|---------------------------------------------------------------------------|-------------|----------------------------------------|
| 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/lhubfs/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, https://kcci.gr
[11] Serbian Chamber of Commerce, https://nis.pks.rs/
[12] https://allcute.eu/en/publications