ICT engineering study programs to meet modern society needs: Erasmus+ project BENEFIT

Matej Zajc[1], Aljo Mujčić[2], Andrea Tonello[3], Vlado Delić[4], Mladen Koprivica[5], Snježana Rimac Drlje[6], Urban Burnik[1], Nermin Suljanović[2]

[1]University of Ljubljana, FE, Tržaška 25, SI-1000 Ljubljana, Slovenia
[2] University of Tuzla, FET, Franjevačka 2, 75000 Tuzla, B&H
[3] University of Klagenfurt, NES, Lake Side Park B02 – A-9020 Klagenfurt, Austria
[4] University of Novi Sad, FTN, Trg Dositeja Obradovića 6, 21000 Novi Sad, Serbia
[5] University of Belgrade, ETF, Bulevar kralja Aleksandra 73, Beograd, Serbia
[6] University of Osijek, FERIT, Kneza Trpimira 2b, 31000, Osijek, Croatia

E-pošta: matej.zajc@fe.uni-lj.si

Abstract **-** In this paper, we briefly present Erasmus+ KA2 Capacity Building project BENEFIT, targeting ICT engineering study programs in Western Balkan region. Project partners work on improving ICT engineering education at participating HEIs, while following international guidelines, industry needs and student expectations. Paper outlines project goals and highlights some significant efforts and achievements.

1 Introduction

Engineering education is consistently evolving to meet the demands of society, with a focus on industry needs [1, 2]. There are many challenges and constraints to global progress of engineering education, among others related to interdisciplinarity of programs, implementation of efficient approaches to active learning, and focus on teaching achievements. Constantly changing conditions in the job market require that Higher Education Institutions (HEIs) continuously improve engineering education.

For the last decade, the BENEFIT project partners identified lowered interest in telecommunication studies in the south-eastern Europe – Western Balkan region. This trend is at least partially a consequence of telecommunication industry passing through significant change [3].

Furthermore, novel technologies such as Internet of things and cloud technologies are demanding skills and expertise reaching beyond the traditional telecommunication engineer profile towards the information and communication technologies (ICT) expert trained to understand and respond to new information-centric era.

While ICT is a pillar of modern society, the industry has difficulties to find sufficiently trained professionals [1]. Industry is finding alternative ways to rising demand in the ICT sector, while universities strive to modernize teaching methodologies and infrastructures. To properly address these circumstances, telecommunications engineering studies require evolution towards more ICT oriented studies in the Western Balkan region and better alignment with the regional industry needs. A comprehensive approach requires that all stakeholders are involved, namely teachers, industry, public authorities as well as students, whose expectations need to be addressed [1-3]. Institutional culture greatly affects how teaching staff address these issues [2]. To overcome such demanding challenges the teachers in Western Balkan need opportunities for inter-institutional collaboration, as for example provided via Erasmus+ KA2 Capacity Building program.

In this paper, we present Erasmus+ KA2 Capacity Building project BENEFIT (2017-2021), targeting ICT engineers' profile to meet modern society and industry needs [3]. Paper presents project goals and scope, as well as introduces the consortium in Section 2. In Section 3 some significant efforts and results are highlighted. Section 4 provides discussion and conclusions.

2 Project BENEFIT overview

2.1 Goals and aims

With the aim to collaboratively work on above mentioned issues the BENEFIT partners titled the project Boosting the telecommunications engineer profile to meet modern society and industry needs, focusing on ICT engineering education in the region, while following international guidelines, industry needs and student expectations. University of Klagenfurt is coordinating the project [3].

Motivation for BENEFIT project is to connect regional universities that provide telecommunication and ICT engineering programs with the goal to make their study programs more attractive and adapted to regional industry. A common HEI-industry e-platform is established acting as a web repository of class and other materials [4].

Main project goals can be summarized as:

1. Modernization of telecommunications/ICT engineering study programs,
2. Adoption of modern teaching methodologies,
3. Improved cooperation between HEIs and the industry,
4. Creation of joint university-industry labs.

Within BENEFIT project, we have identified several paths to achieve the project goals, among others:

- Extension of cooperation between HEIs and regional industry beyond current industry project partners
- Modernization of existing study programs including enhancement of existing and introduction of new courses
- Development and adoption of new teaching methods and tools
- Implementation of trainings for both teachers and students as a continuous process.

2.2 BENEFIT consortium

The consortium consists of academic partners from four countries [3]. From Western Balkan six universities from Bosnia and Hercegovina - University of Tuzla, University of Sarajevo, and University of Banja Luka, and from Republic of Serbia - University of Belgrade, University of Novi Sad, and University of Niš. From EU three universities are leading the process, namely, from Austria University of Klagenfurt, from Slovenia University of Ljubljana, and from Croatia University of Osijek.

Besides HEIs, there are also important regional industry partners involved in the project, namely, Ericsson Nikola Tesla Zagreb, Cisco Belgrade, Bicom Zenica, BIT Centar Tuzla, NiCAT Niš and RT-RK Novi Sad. Several companies are also serving as associated partners AlfaNum, Vojvodina ICT Cluster and Zesium Mobile.

3 Study programs in the field of telecommunications and ICT

As one of the first steps current study programs at all partner HEIs were carefully analyzed. The acquired data has been analyzed aiming at identifying current status of the academic study programs. The analyzed data gives an insight into main similarities and differences between the programs, as well as existing deficiencies. For example, EU HEIs programs consist of 3 years for the first cycle (bachelor) and 2 years for the second cycle (masters), while all programs in Serbia as well as in Bosnia and Herzegovina (besides program at the University of Sarajevo) 4 years for the first cycle and 1 year for the second cycle. This fact can be an obstacle for harmonization of programs and future establishment of joint studies between EU and WB partner institutions.

The analysis showed that although study programs provide good theoretical background, there is a lack of appropriate laboratory equipment and new methodologies aimed at active learning, as well as adequate collaboration with industry to provide the students with the practical skills needed today [3, D1.1]. Another deficiency of existing programs is that there is no first-year course directly related to modern telecommunications technologies that would encourage students to enroll in the ICT field of study. Furthermore, students usually perceive current programs as classic telecommunications programs because state of the art ICT topics are not sufficiently emphasized.

3.1 Bologna process

The modernization of telecommunications engineering study programs must provide international perspectives and reflect a global view of new telecommunications technologies related to developments in electronic, computer and software engineering.

There are several curriculum guidelines provided by national and international institutions such as ABET, ACM, where within the EU the Bologna process is most relevant. The aim of the BENEFIT project is to follow the Bologna process considering autonomy of the universities while capturing changing needs of industry, expectations of students and society. These inputs were collected during the project, among others via open day events, as for example, Open event Ljubljana 2018 with representatives of students, University of Ljubljana career center, Slovenian Chamber of commerce and HR personnel from the industry as well CMPEPIUS [3].

Main aspects of the Bologna process relevant for the BENEFIT project are efforts towards comparable degrees, mechanisms for transferable academic credits, positioning students as essential partners, promotion of inter-institutional cooperation, and various mobility schemes. In addition, other guidelines are also consulted, as for example following the outline of ACM computer engineering body of knowledge as a framework for our work [5]. As a result of analysis of current study programs from all participating HEIs a three-level hierarchical structure was developed with seventeen knowledge areas. Based on this body of knowledge later knowledge units were identified and implemented in selected existing and new courses.

3.2 Framing the regional industry needs

To have better insights into local and regional industry needs related to ICT engineering studies a survey was conducted among 49 companies in the region. The survey has been prepared to collect information on job market/needs and to map skills and knowledge areas required from ICT engineers and specialists in the ICT sector. The aim was to gather relevant information from industry in the region so that academic partners would have current information in the process of modernization of the study programs [3, D1.1].

The survey included questions related to professional skills, which are most important for an ICT engineer and skills that current engineers are lacking most. Companies have reported that majority are facing problems with ensuring adequate skills of their employees as well that they are facing difficulties in filling vacancies.

Related to the ICT engineering profile they report insufficient supply of qualified candidates with adequate skills, following lack of work experience and on the other side insufficient salaries to attract most qualified candidates.

We have also investigated relevance of individual knowledge areas covered by current study programs in telecommunications and ICT engineering to better inform current and future improvements of the study programs.

3.3 Updated and novel courses

The body of knowledge was created on the existing university study programs with a vision of modernization of these study programs at partner universities. As part of the first preparatory work package seventeen knowledge areas were defined based on analysis of existing study programs [4, 5]. The knowledge areas include topics in telecommunication/ICT engineering as well as core sciences. Each knowledge area consists of knowledge units further composed of topics and learning outcomes.

The body of knowledge is the basis for creating new courses and modernizing existing ones. The course may include knowledge units from one or more knowledge areas, depending on the learning outcomes for a given course.

As writing the learning outcomes is one of the fundamental elements in the Bologna process all courses within BENEFIT project were prepared using the guide for writing and using learning outcomes [6]. As part of the project activities, a teacher training was conducted in 2019 as a full day workshop at University of Ljubljana, University of Banja Luka and University of Osijek. As part of the internal evaluation of the two-day event, comments from the participants were very positive, indicating that such trainings are needed and well accepted by the academic staff. After the event certificates of attendance of the workshop were provided to the participants.

At first cycle level, 32 courses were modernized, and 8 new courses were introduced. These courses covered 10 knowledge areas. At second cycle degree level, 11 courses were modernized, and 13 new courses were introduced. These courses fit into 8 knowledge areas. Some of these novel and modernized courses for ICT study programs are also used as elective courses at other study programs at universities.

The process of creating a new course or upgrading an existing course was defined in the following steps:

1. Determine Knowledge Areas that cover objectives and outcomes of the course,
2. Select knowledge units and sub-units from Telecommunication/ICT Body of Knowledge,
3. Prepare course materials and select appropriate teaching methodologies,
4. Upload material to the e-platform.

The preparation of new educational materials also involves introduction of new teaching methodologies (Section 3.4) and requires modern laboratory equipment for the realization of accompanying lab sessions (Section 3.5). All teaching materials are uploaded to the e-platform and are accessible to all students from participating universities. The process was developed and trained within local and regional workshops.

3.4 Teaching methodologies

In modern teaching, teachers become facilitators. They need to provide additional class readings to facilitate discussions, plan individual and group project work in the class and outside the class, facilitate interaction with the industry and society, and give opportunities to students to present their work and to tutor other students [2].

Therefore, the process of updating the existing courses as well as the development of new courses also require introduction of new, more active approaches to teaching and learning. Identification of appropriate teaching methodologies for ICT engineering studies resulted in a collection of nearly 30 innovative teaching/learning methodologies, grouped into three groups [3, D3.1]:

- Student oriented,
- Technology oriented,
- Activity oriented (the largest group).

Several workshops were organized to present and demonstrate selected teaching methodologies to teachers and assistants, including the project meetings and conferences in Tuzla (InTsinkt), Novi Sad (ZINC), Osijek, Banja Luka, Belgrade (TELFOR) and Sarajevo.

From investigated teaching methodologies teachers have selected appropriate teaching methodologies for 62 novel or enhanced courses to be implemented and investigated in the classroom. The most frequently selected teaching methodologies were: Project-based learning, Active learning, Research-related teaching, The case method, and Teaching support via websites and social media. However, the selection of teaching methodologies has been made before the Covid-19 pandemic time. An analysis of changes in selection of teaching methods has been conducted and proved that online courses (video lectures), creative assignments, self-learning, pre-lecture based learning, as well as audio-library have some advantages under the circumstances of remote-online classes. More details on our experience with the teaching methodologies for ICT engineering education are available in [7].

In order to make all relevant information and materials available to students and other interested stakeholders, a web platform with an official project website and specialized e-platforms was created [3, 4, 8]: Study programs web portal, Teaching material repository, Industry catalog and Industry information portal.

3.5 New university-industry labs

An important part of the project activities is creation of novel thematic joint university/industry labs. All WB HEIs are involved in the process of joint university-industry lab development: University of Banja Luka: “Signal Processing in Telecommunications Lab” in collaboration with Bicom and AlfaNum; University of Sarajevo: “Telecommunications Lab” in collaboration with BIT Centar; University of Tuzla: “VoIP Services Lab” in collaboration with Bicom and BIT Centar; University of Belgrade: “Networks and IoT Lab” in collaboration with CISCO; University of Niš: “Machine-

to-Machine Communication Lab" in collaboration with NiCAT; University of Novi Sad: "Wireless Communications and Information Processing Lab" in collaboration with RT-RK and Saga – the laboratory will be located in the Scientific and Technology Park with opportunity to collaborate with many other ICT industrial partners.

The aim of these new joint university-industry labs is to support laboratory practice with modern state of the art equipment. Joint activities with the industry will be implemented through the specific agreements related to operation of these joint labs, as for example industry trainings for students and upgrading the capacity of teaching staff. The partners collaborate in the development of teaching methodologies that involve participation of industrial partners, including joint project tasks for students, implementation/development challenges, hackathons, and team competitions.

Practicums and promotional video lectures are under preparation; some of them are already posted on e-platform [4, 8]. Most of new courses have defined topics for student projects and theses in collaboration with the industry. Moreover, several summer schools, internships, hackathons, and student competitions have been organized [3, D4.1], more in 2019 and less in 2020 due to pandemic. These joint labs activities will continue also after the project lifetime.

3.6 Quality management of the project

Relevant quality control measures are a formal requirement within Erasmus+ assessment criteria and ensure efficacy of project actions in all project stages. In order to persistently monitor the project actions and to foster continuing BENEFIT activities throughout and after the project duration, Quality Assurance Plan (QAP) was established [8]. QAP provides quality measures for monitoring project implementation based on project indicators. The Plan systematically addresses project documentation and reporting, defines assessment of deliverables, standardizes event reporting and analysis, provides publicity control, and ensures consistency of project documents through standardized templates.

4 Discussion and Conclusion

Project BENEFIT will influence the future development of ICT engineering study programs at the participating institutions by enhancing and modernizing engineering education at both first and second cycle levels. The activities conducted by the project partners since 2017 promote regional cooperation and mobility, training of teaching staff, inclusion of students and increased cooperation with local and regional industry.

Our work started with the consolidated ex-ante analysis of current study programs and industry needs and analysis of national and international guidelines aimed at transition of telecommunications engineer profile towards more ICT oriented studies. Current study programs are influenced with modernization of selected courses and introduction of new courses based on establishment of novel university-industry labs.

During the project, the importance of long-term regional relationship and collaboration between HEIs has become even more evident. Collaboration between regional universities as well as between universities and regional industry are supported through the common HEI-industry e-platform [4, 8]. Project offers increased opportunities to our students with connections with industry and regional participating universities.

The activities related to improvements of study programs need to remain continuous process. During the project, we improved our understanding of importance to frame industry needs, increase involvement of students in every activity, engage teaching staff, etc. Joint industry-university labs facilitate activities far beyond individual course needs enabling better cooperation with industry and offering support to research activities.

Acknowledgments

This work was carried out within the project BENEFIT - Boosting the telecommunications engineer profile to meet modern society and industry needs - 2017-2021 - cofounded by the ERASMUS+ KA2 program – grant agreement n. 585716-EPP-1-2017-1-AT-EPPKA2-CBHE-JP.

References

[1] Aničić, K.P., Divjak, B. and Arbanas, K., 2016. Preparing ICT graduates for real-world challenges: results of a meta-analysis. IEEE Transactions on Education, 60(3), pp.191-197.

[2] Carberry, A.R. and Baker, D.R., 2018. The impact of culture on engineering and engineering education. In Cognition, metacognition, and culture in STEM education (pp. 217-239), Springer.

[3] Project BENEFIT - Boosting the telecommunications engineer profile to meet modern society and industry needs, https://www.project-benefit.eu/, accessed August 2020.

[4] E-platform of the project BENEFIT, https://www.project-benefit.eu/eplatform/, accessed Aug. 2020.

[5] Curricula Recommendations: Computer Engineering Guidelines 2016. ACM, 2016. Available at: https://www.acm.org/binaries/content/assets/education/ce2016-final-report.pdf, accessed Aug. 2020.

[6] Kennedy, D. Writing and using learning outcomes, Quality Promotion Unit, UCC, 2007.

[7] Delić, V. et al. Teaching Methodologies for ICT Engineering Education before and after the Pandemic Developed in the BENEFIT Project, ERK, Portorož, Slovenia, Sep. 2020.

[8] Rimac-Drlje, S., Žagar, D. BENEFIT Industry information portal - a service for better cooperation between universities and companies in the teaching process, ERK, Portorož, Slovenia, Sep. 2020.

[9] Burnik, U. et al. Quality management of Erasmus+ BENEFIT project, ERK, Portorož, Slovenia, Sep. 2020.