Teaching Methodologies Adopted at the BENEFIT Project for ICT Engineering Education Before and During Covid-19

Vlado Delić[1], Aljo Mujčić[2], Nataša Maleš-Ilić[3], Zdenka Babić[4], Dušanka Bošković[5], Mladen Koprivica[6], Drago Žagar[7], Matej Zajc[8], Nermin Suljanović[2], Andrea Tonello[9]

[1] University of Novi Sad, FTN, Trg Dositeja Obradovića 6, 21000 Novi Sad, Serbia
[2] University of Tuzla, FET, Franjevačka 2, 75000 Tuzla, B&H
[3] University of Niš, FEE, Aleksandra Medvedeva 14, 18000 Niš, Serbia
[4] University of Banja Luka, FEE, Patre 5, 78000 Banja Luka, B&H
[5] University of Sarajevo, FER, Zmaja od Bosne bb, 71000 Sarajevo, B&H
[6] University of Belgrade, ETF, Bulevar kralja Aleksandra 73, Beograd, Serbia
[7] University of Osijek, FERIT, Kneza Trpimira 2b, 31000, Osijek, Croatia
[8] University of Ljubljana, FE, Tržaška 25, SI-1000 Ljubljana, Slovenia
[9] University of Klagenfurt, NES, Lake Side Park B02 – A-9020 Klagenfurt, Austria
E-mail: vlado.delic@uns.ac.rs

Abstract. *Covid-19 pandemic has changed the life in many aspects, including the teaching/learning methodologies. The Erasmus+ KA2 project BENEFIT (2017-21) has been aimed at improving engineering education in the area of ICT, but its goals and teaching methodologies were selected before the pandemic. The last project year covers two semesters of adoption of developed novel and enhanced courses with new labs and teaching methodologies facing new circumstances. The changes in the selection of teaching/learning methodologies and methods for lab sessions and their adoption in modernized ICT engineering courses are analysed in the paper.*

1 Introduction

The project "Boosting the telecommunications engineer profile to meet modern society and industry needs / BENEFIT" (October 2017 – February 2021) is an Erasmus+ KA2 Capacity Building project targeting ICT engineering study programmes in the Western Balkan region [1-4]. The project has been motivated by changes in telecommunication industry and novel technologies such as 5G, IoT and Edge-Fog-Cloud since they are demanding new skills and expertise in the domain of information and communication technologies (ICT) and requiring experts trained to understand and respond to the new information-centric era [1].

The three main goals of the BENEFIT project are:

G1 To modernize teaching methodologies by adopting novel learning/teaching methods,
G2 To upgrade the lab infrastructure through the development of novel thematic industry-academia labs,
G3 To increase the attractiveness of ICT studies through the development of a joint e-platform.

Many activities have been conducted in the first two years of the project timeline and resulted in 64 novel and enhanced courses (21 novel and 43 modernized) at the 1st study cycle level (40 bachelor courses) and the 2nd cycle level (24 master courses) [1], [2, D2.1]. These 64 courses exploit both new teaching/learning methodologies and joint academia-industry labs established at the six Western Balkan universities. The courses have just been accredited, while the joint labs are negotiated by the operational agreements between university and industry partners [1], [2, D3.2]. The teaching/learning methods have been selected by teachers of the 64 novel and modernized courses from a collection of nearly 30 innovative teaching/learning methodologies that are suitable for ICT engineering education [2, D3.1]. The teaching material for most of the 64 courses has been prepared and posted on a common HEI-industry e-platform which is acting as a web repository of class material and also provide many important information related to study programmes and cooperation with industry partners [3]. The project results have been promoted at national and international level, e.g. [4, 5].

However, the BENEFIT project goals, methodology and activities were designed and planned a few years before the Covid-19 pandemic, while the adoption of results, the delivery of new courses based on novel teaching methodologies and the exploitation of the improved lab infrastructure, are facing new circumstances caused by the pandemic. For example, the selection of novel teaching/learning methodologies from the collection has been made without the experience we gathered with the pandemic. This has caused changes in the selection of the teaching/learning methodologies and methods for lab sessions during the Covid-19 pandemic. The changes in teaching methodologies are determined and carefully analyzed in their adoption in the last project year, as described in this paper.

After the introduction which presented the subject of this paper, Section 2 presents the collection of teaching/learning methodologies that was analyzed and considered suitable for ICT engineering education. The initial selection rate of teaching methodologies made by the teachers of the 64 novel and enhanced courses is given in Subsection 2.1, while their plan for changes in the selection and adoption of novel teaching/learning methodologies is presented and analyzed in Subsection 2.2. Section 3 summarizes the discussion and conclusions.

2 Teaching methodologies suitable for ICT engineering education

A set of BENEFIT project activities at WP3 "Modernization of teaching methodologies and infrastructures" is related to the deliverable D3.1 "Development of modernized teaching methodologies". Relationship among WP3 tasks, D3.1 and other deliverables, as well as their impact to the three main project goals are shown in Figure 1. D3.1 is based on the development of innovative training methods involving industry (T3.3) and the development of learning/teaching methods based on student competitions, and development of student challenges and hackathons (T3.4), as well as the adoption of new learning/teaching methods, tools, ICT best practices in teaching (T3.1).

Figure 1. Relations among the project deliverables and WP3 tasks, as well as their contributions to the project goals

After clear identification of limitations of traditional teaching/learning methods on the engineering education (in the preparatory WP1), a collection of nearly 30 novel and innovative teaching methodologies were selected and described as potentially more suitable for ICT engineering education, including usage of e-tools, online courses, social media, cloud-based platforms, etc. [2, D3.1]. Particular attention has been given to the teaching methodologies that involve active participation of industrial partners such as internships, co-advised student projects and theses, that stimulate creativity, innovation and entrepreneurship of students.

Education in engineering disciplines requires a balance between limited time resources and the increased amount of knowledge about a specific topic. Furthermore, the innovations and intellectual property are becoming important as never before. The deliverable D3.1 provides an overview of 30 innovative teaching methodologies that can be adopted as novel/interesting

teaching/learning methods for courses in the study programmes for Telecommunications Engineering at the six universities in Serbia and Bosnia and Herzegovina (selected in WP2). The joint result of WP1, WP2 and WP3 is a collection of teaching material for new and modernized courses [2, D3.3] as an impact to the first project goal G1 – to modernize teaching methodologies by adopting novel learning/teaching methods.

The activity to establish of a web servise (T3.5) as a web repository for class and lab sessions material, recorded remote classes, and network of audio libraries [2, D3.4] contributes to the goal G3 – to increase the attractiveness of ICT studies through the development of a joint e-platform. Finaly, the activity to the creation of six joint University-Industry Labs (T3.2) is a direct contribution to the goal G2 – to upgrade the lab infrastructure through the development of novel thematic joint industry-academia labs.

The selected teaching/learning methodologies are divided into three groups oriented to 1) student (S1-S7), 2) technology (T1-T5), or 3) activity (A1-A14), Table 1. More details for each of near 30 teaching/learning methodolgies are given in their references in [2, D3.1].

Table 1. The list of proposed teaching methodologies [2,D3.1] and the number of courses whose teachers have selected them: Before and During the Covid-19 pandemic

Teaching Methodolgies Adopted at the BENEFIT project	Before	During
1) Student-Oriented Teaching Methodologies:		
S1 The case study method	12	12
S2 Teaching workshops	9	4
S3 Flipped or inverted classroom	7	3
S4 Brainstorming	6	3
S5 Teaching through student competitions	3	0
S6 Student-centered education	2	1
S7 Teaching through debate	1	0
2) Technology-Oriented Teac. Methodologies:	**B%**	**A%**
T1 Teaching support via websites & social media	10	22
T2 Online courses (Video lectures)	6	22
T3 Learning method based on audio library	3	3
T4 Web-based engineering experiments	0	0
T5 Teaching through games (Gamification)	0	0
3) Activity-Oriented Teaching Methodologies:	**B%**	**A%**
A1 Project-based learning	41	41
A2 Active learning	28	18
A3 Research-related teaching	24	25
A4 Z to A approach	10	7
A5 Creative assignments	6	8
A6 Pre-lecture based learning	5	6
A7 Peer group/team (Collaborative) teaching	5	0
A8 Work-based learning	2	0
A9 Self-learning	2	3
A10 Curiosity-driven learning	1	1
A11 Teaching following standardization process	1	0
A12 Block schedule	0	0
A13 Patent base oriented syllabus	0	0
A14 Teaching fundamentals through vocation-related examples	0	0

2.1 Selection of teaching methodologies by teachers of ICT engineering courses at six universities

For example, UNS i.e. the Chair of Telecommunications and Signal Processing (40 members) of the Department of Power, Electronic and Telecommunication Engineering (200) at the Faculty of Technical Sciences (1.200), University of Novi Sad (5.000), provides 98 courses at 7 study programmes, mostly (51) at the Study programme of Power, Electronic and Telecommunications Engineering. Among 49 courses at the Modules of ICT and Signal Processing, there are 21 courses at the 1st study cycle, 15 courses at the 2nd cycle, and 13 at the 3rd cycle (doctoral studies). Out of these 49 courses, 10 courses are created or improved at the project BENEFIT (more than 20%), 6 at the 1st cycle (3 novel and 3 enhanced courses) and 4 at the 2nd cycle (4 novel courses). Most of them are based on new equipment in the Wireless Communications and Information Processing Lab with joint activities and agreements with industry, beginning from RT-RK and Saga companies.

The teaching/learning methodologies have been selected by the teachers of these 10 courses developed at UNS within the BENEFIT project: 8 × A3 Research-related teaching (5/6 at the 1st cycle, 3/4 at the 2nd), 7 × both A1 Project-based learning and A2 Active learning with the same distribution (4/6 at 1st cycle, 3/4 at 2nd), 7 × S1 The case study method (3/6 at 1st, 4/4 at 2nd), 4 × T1 Teaching support via websites and social media, 3 × both S2 Teaching workshops and T2 Online courses (Video lectures), 2 × S6 Student-centred education, while S5 Teaching through student competitions, A4 Z to A approach, and A11 Teaching by following the standardization process (Learning by experiments with open hardware and software testbed) have per 1 choice.

Similar data are gathered for all other Western Balkan universities involved in the BENEFIT project [2].

All 7 **student-oriented teaching methodologies** have been selected by teachers of 64 novel or enhanced courses at the BENEFIT project. S1 The case study method is the most popular in the group (12 out of 64 courses) – equally before and during the pandemic. All other student-oriented teaching methodologies have decreased selection rate during the pandemic: S2 Teaching workshops (9→4 courses), S3 Flipped or inverted classroom (7→3), S4 Brainstorming (6→3) and S5 Teaching through student competitions (3→0 courses).

Five **technology-oriented teaching methodologies** are chosen and described in the collection. T1 Teaching support via websites and social media (10→22 courses) become more and more popular with students from Y and Z generation which lives on social networks. T2 Online courses (Video lectures) (6→22) have the greatest increase in use during the pandemic. Also, T3 Learning/teaching method based on audio library is useful for support since it is easy to recreate new audio-video editions in order to change or improve only some details [5]. Video lectures are recorded as they were performed and it is not simple to make modifications and change some parts since this would require record sections of the lectures.

The largest group of **activity-oriented teaching methodologies** has the most popular ones: A1 Project-based learning (41→41) and A3 Research-related teaching (24→25) which is the most popular at the 2nd level (18 out of 24 master courses). The increase in selection rate have A5 Creative assignments (6→8), A6 Pre-lecture based learning (5→6) and A9 Self-learning (2→3), while several teaching methodologies from the activity-oriented group have great decrease: A2 Active learning (28→18), A7 Peer group/team teaching (Collaborative teaching) (5→0), A4 Z to A approach (10→7) and Work-based learning (2→0).

2.2 Changes in the selection of teaching methodologies due to the pandemic

There are teachers at the 64 new courses who choose the same teaching methodologies before and during the pandemic, but adapted to work remotely and through video platforms that they used for teaching.

Table 1 provides information of changes in the selection rate of teaching/learning methodologies by the teachers of 64 novel and enhanced courses at the project BENEFIT. It is one of the main results of presented research which was conducted during the summer 2020, i.e. between the spring semester with the first experience in the new circumstances in higher education due to the pandemic and the next autumn semester.

After one semester experience with the pandemic, the selection of teaching/learning methodologies has been changed so that T2 Online courses (Video lectures) has become usual for almost all courses, while some of teaching/learning methodologies become more or less frequently selected. Many teachers have removed some teaching methodologies from their plan such as A2 Active learning (-10), A7 Peer group/team teaching (Collaborative teaching) (-5), S2 Teaching workshops (-5), S3 Flipped or inverted classroom (-4), S4 Brainstorming (-3), A8 Work-based learning (-2). On the other side, apart from T2 Online courses (Video lectures) (+16) and T1 Teaching support via websites and social media (+12), other teaching/learning methodologies have become more common: A5 Creative assignments (+2), A6 Pre-lecture based learning (+1), and A9 Self learning (+1), while some methodologies keep a high rate such as A1 Project-based learning (41→41) and A3 Research-related teaching (24→25), Figure 2.

Different e-learning tools and platforms are widely used for distribution of learning materials, conversation with students, as well as their testing and evaluation, like Moodle or Sova. The e-platform of the project BENEFIT has also become popular as a web repository for teaching material as well as the connection between university and ICT industry in the region. The teachers use different platforms for study group support, discussion and opinion pooling, which enables chat, conversations, meetings and video conferencing including online courses and recordings of video lectures (Microsoft Teams, Google Meets, Cisco Webex, Zoom, Skype, Discord). Some of teachers also use web-sites which offers video streaming, like Youtube.
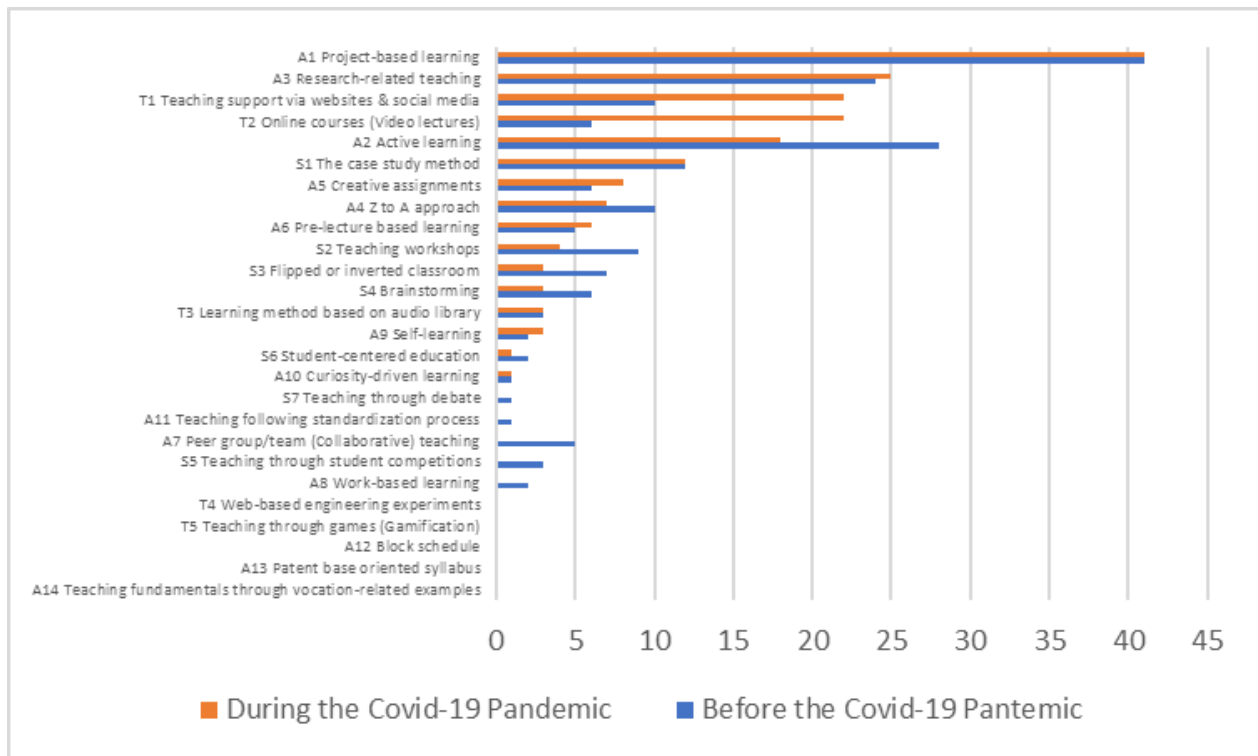
Figure 2. Frequency of selection of the teaching methodologies before and during the Covid-19 pandemic out of 64 novel and enhanced courses which are developed at the BENEFIT project

Regarding the Lab sessions, most of teachers at the project BENEFIT prefer a) Assigning small projects that can be carried out at home, while some of them prefer b) Offering remote access to simulation and HW design tools or c) Operating labs remotely with only the teacher or technician in the lab (most equipment can be operated remotely). Simulation software is also popular in BENEFIT labs, but their use is more effective in live. From the logistics point of view, if teaching will be carried out with physical presence and social distancing stay required, the smaller groups will be necessary with shorter duration labs and multiple sessions.

3 Discussion and Conclusion

Changes in teaching and training due to the Covid-19 pandemic have to be more significant in the engineering education field since it needs a lot of laboratory work and development of practical skills.

A range of innovative teaching methodologies and online/e-learning tools are reselected at the project BENEFIT and presented here as more convenient for exploitation in the new circumstances. The largest changes in the selection are noticed for the teaching methods and e-tools that are closer to Online courses. Due to the pandemic, the project has produced more video lectures than in the initial plan. Students have to work more on Pre-lecture based learning and Self-learning methods, while teachers have to work more as facilitators on the Creative assignments and creation of more interactive online lectures and tests for students. On the other side, Peer group/team teaching, Teaching workshops and Work-based learning have to be postponed and redesigned using virtual teaching platforms.

The selected courses of modernized study programmes in the field of ICT/Telecommunication Engineering will be adopted in the winter semester 2020. Their impact to the industry and society needs will be followed till the end of the project and afterwards.

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Acknowledgements