Project:	Boosting the telecommunications engineer profile to meet modern society and industry needs [BENEFIT]
Project ID:	585716-EPP-1-2017-1-AT-EPPKA2-CBHE-JP
Work Package 3:	Modernization of teaching methodologies and infrastructures
Title:	D3.1 Development of modernized teaching methodologies
Lead Organization:	UNS
Participating Organizations:	UNI-KLU, UL, FERIT, UBL, UNSA, UNTZ, UB, UNI, ENT, BICOM, BIT, CISCO, NiCAT, RT-RK
Editors:	A. Tonello, M. Zajc, D. Žagar, V. Delić
Contributors:	V. Delić, D. Vukobratović, I. Kaštelan, M. Narandžić, M. Sečujski, G. Marković, J. Ćertić, M. Koprivica

Deliverable data	Work Package and Outcome ref.nr	WP3 D3.1
	Title	Development of modernized teaching methodologies
	Type	☒ Teaching material ☐ Event ☒ Learning material ☒ Report ☒ Training material ☒ Service / Product
	Description	The report describes a number of selected novel and innovative teaching methodplogies. Particular attention has been focused on the learning/teaching methods that involve industrial partners that stimulate creativity, innovation and entrepreneurship of students. New learning/teaching methods based on student competitions, student challenges and hackathons are described.
	Date	14.04.2020
	Language	English and Serbian (Bosnian/Croatian)
Target groups	☒ Teaching staff ☒ Students ☒ Trainees ☐ Administrative staff ☒ Technical staff ☐ Librarians ☒ Industry partners, WB Higher education authorities	
Dissemination level	☐ Department / Faculty ☐ Local ☐ National ☐ Institution ☐ Regional ☒ International	
Lead Organization	UNS	
Participating Organizations	UNI-KLU, UL, FERIT, UBL, UNSA, UNTZ, UB, UNI, ENT, BICOM, BIT, CISCO, NiCAT, RT-RK	
Task	T3.1 Adoption of new learning/teaching methods, tools, ICT best practices in teaching (Task leader: UNS). T3.3: Development of innovative training methods involving industry (RT-RK). T3.4: Development of learning/teaching methods based on student competitions, and development of student challenges and hackathons (UNS).	

Revision History				
Version	Date	Author(s)	Organization(s)	Brief description of change
01	15.01.2019	V. Delić, D. Vukobratović and UNS team	UNS	Initial draft
02	28.02.2019	Z. Babić, I. Kaštelan, G. Velikić, N. Maleš-Ilić	UBL, RT-RK, UNI	Contributions to Section 3 and Section 4
03	31.12.2019.	All	All	Section 3 and Section 4
04	20.03.2020.	D. Vukobratović, I. Kaštelan	UNS, RT-RK	Section 5 and Section 6
05	31.03.2020.	M. Narandžić, V. Delić, M. Sečujski	UNS	Section 4, Section 2 and Conclusion
06	10.04.2020	G. Marković, J. Ćertić, M. Koprivica	UB	Section 7
07	14.04.2020	A. Tonello, M. Zajc, D. Žagar	UNI-KLU, UL, FERIT	External review revisions
release 1	01.09.2020			

Table of Contents

1. Introduction

The deliverable D3.1 "Development of modernized teaching methodologies" reports the results of the WP3 activities related to the adoption of novel learning/teaching methods. To this aim, project partners have been involved in a set of project activities including workshops, discussion panels and mutual visits, that have provided the teaching staff of higher education institutions in the Western Balkans with an opportunity to master novel and innovative teaching methods, advanced lab solutions, development of joint academic/industrial teaching methodologies, usage of e-tools, online courses, social media, cloud-based platforms, etc. In the development of modernized teaching methodologies particular attention has been given to teaching methodologies that involve active participation of industrial partners. The literature related to innovative teaching activities that stimulate creativity, innovation and entrepreneurship has been analysed and conventional and unconventional teaching practices have been analysed for comparison, including lecturing and examination through project tasks, implementation/development challenges, hackathons (thematic student challenges) and team competitions, all of which will be prepared in collaboration with industrial partners.

The motivation for the modernization of the teaching methodologies comes principally from the identified limitations of traditional teaching/learning methods, including, most notably, the following:

- Traditional teaching in classroom using a blackboard, chalk and talk is usually "one way flow" of information, and fails to engage attendees in active participation.
- In turn, the lack of feedback from the students can gradually reduce a teacher's expectation for such a feedback, and lectures may turn into long and tedious monologues.
- For efficiency, course material is often limited to the pre-prepared lectures and text books, which limits the creativity of students in acquiring and recognizing suitable literature for their tasks.
- Lack of engagement, and lack of incentive for acquiring active knowledge on the part of students may degrade into a false belief that it should be sufficient to be present at a lecture to get full effects from it.
- Too much focus may be given to theory, and the connection to real-life applicable knowledge may be lost, which additionally demoralizes the attendees.
- The current education system gives far too much relevance to memorizing skills of students and is not sufficiently concerned with their understanding of the acquired knowledge and ability to apply it to a practical problem.
- Teachers are also less motivated to provide real life examples where the acquired knowledge can be efficiently applied, which reduces the student's ability to recognize that a particular real life situation 'fits' the model learned at the lectures.
- The education system is marks oriented rather than knowledge oriented, in that it evaluates a graduate student primarily through his or her grade point average instead of ensuring the ability of the student to solve a wide range of practical problems and have a sound basis for future education in a narrow field off specialization.

Nevertheless, it has to be mentioned that modern courses in higher education usually need to balance between limited time resources and the increased amount of knowledge about a specific topic. This is especially true in the case of applied and engineering disciplines, where the pace of technological development is much higher than it used to be just a few decades before. Therefore, it can be concluded that there is a need for a new type of syllabus that should, on one side, cover the main topics, but, on the other side, also provide sufficient resources and intellectual stimuli for the students to grasp the current state of the art in the field, and give them a sound motivation for hard work that is necessary for becoming an expert in the field. Furthermore, since innovations and intellectual property are becoming important as never before, an employee with good ideas is extremely highly valued. It is the task of the education system to develop an individual with ideas, rather than an individual capable of reproducing the knowledge, understanding it at a level that is insufficient for its efficient usage.

The results from the deliverable D3.1 will be used for the modernization of teaching methodologies at both novel and modernized courses, together with six new joint academia-industry laboratories:

- University of Banja Luka: "Signal Processing in Telecommunications Lab" in collaboration with Bicom and AlfaNum;
- University of Sarajevo: "Telecommunications Lab" in collaboration with BIT Centre;
- University of Tuzla: "VoIP Services Lab" in collaboration with Bicom and BIT Centre;
- 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.

More detailed report related to the six joint labs is given in the deliverable D3.2 "Creation of 6 joint University-Industry Labs", that will describe the acquired equipment and established facilities as direct contribution to the project goal G2 "Upgrade the lab infrastructure through the development of novel thematic joint industry-academia labs" (Fig. 1).

The deliverable D3.1 as a report is organized in eight sections. After the Introduction, the Section 2. shows both the objectives of the deliverable D3.1 and relations to the five WP3 tasks as well as connections to other WPs and, altogether, their contributions to the three main project goals. The Section 3. gives an overview of 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 as well as Bosnia and Herzegovina. The Section 4. gives an overview of platforms and tools used for teaching which are preferred as online/ e-learning tools at the six universities. The development of learning/teaching methods based on student competitions, challenges and hackathons are described in the Section 5, while a case study of the block-based course is proposed in the Section 6, as an innovative training method involving industry. The summary and main conclusions are drawn in the Section 7. The last Section 8. contains a list of references with more details related to the selected teaching methodologies that are adopted for modernized and novel courses introduced to the study programmes at the six WB universities that participate at the BENEFIT project.

2. Objectives of the Deliverable

Identification of modern teaching methodologies was the first activity in the WP3. They will be considered in the project and introduced within a selected number of both novel and modernized courses at six higher education institutions in the Western Balkans. The courses have been selected from different Knowledge Areas covered by the Body of Knowledge of Telecommunications Engineering as defined in WP2. A range of innovative teaching methodologies and online/e-learning tools will be adopted for the selected courses that spread across the Knowledge Areas.

The main Objective of this deliverable has been to identify a manageable set of innovative teaching technologies that are convenient for exploitation at selected courses of modernized study programmes in the field of Telecommunication Engineering. Namely, the state-of-the-art literature offers an extremely wide and diverse range of teaching/learning technologies, from inverted classrooms to student challenges and competitions. The objective of the deliverable was to focus on those that are particularly suitable for implementation in the context of the BENEFIT project, and together with other WPs and activities, to give contributions to the main three project goals.

The relations among WP3 tasks and deliverables, their connections to other WPs, as well as their contributions to the project goals are shown in the Fig. 1.

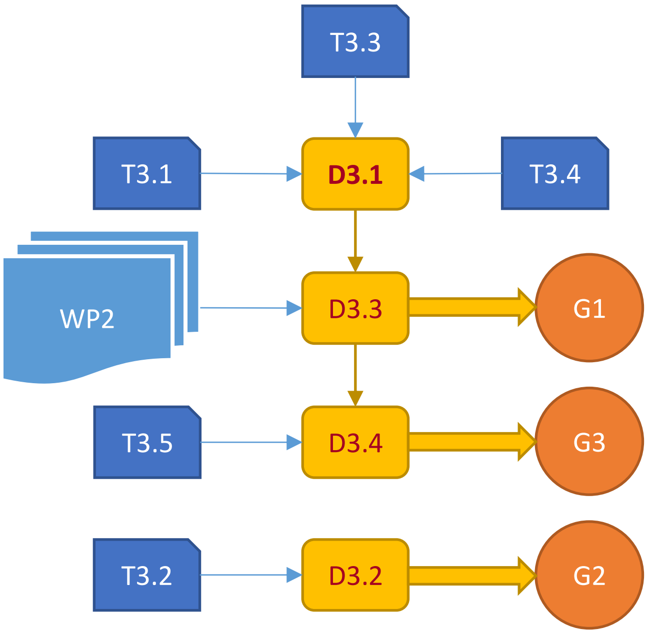


Figure 1. WP3 deliverables and their relations to both WP3 tasks and other WPs, as well as their contributions to the three main project goals

The deliverable D3.1 "Development of modernized teaching methodologies" has resulted from three WP3 tasks:

- T3.1: Adoption of new learning/teaching methods, tools, ICT best practices in teaching,
- T3.3: Development of innovative training methods involving industry and
- T3.4: Development of learning/teaching methods based on student competitions, and development of student challenges and hackathons.

Their titles show focus to the development of joint academic/industrial teaching methodologies and learning/teaching methods that stimulate creativity and active participation of students.

The deliverable D3.1 with other WPs participates to the deliverable D3.3 "Collection of teaching material for new and modernized courses" and contributes to the project goal G1 "Modernize teaching methodologies by adopting novel learning/teaching methods", as well as to the web service D3.4 "Web repository for class and lab sessions material, recorded remote classes, and network of audio libraries" – contributing also to the project goal G3 "Increase the attractiveness of ICT studies through the development of joint e-platform".

The next sections describe the modernized teaching methodologies in more details.

3. Overview of Innovative Teaching Methodologies

We have identified nearly 30 innovative teaching methodologies, i.e., novel/interesting teaching/ learning methods that can be adopted for courses in study programmes for Telecommunications Engineering. The most appropriate and eligible teaching methodologies available in the literature are briefly presented in this section. They are divided into three groups of teaching methodologies oriented to student, activity, or technology.

Table 1. *The list of proposed innovative teaching methodologies*

Student-Oriented Teaching Methodologies:	**Activity-Oriented Teaching Methodologies:**
1) Student-centered education	8) Active learning
2) Flipped or inverted classroom	9) Research-related teaching
3) Teaching through student competitions	10) Project-based learning
4) Teaching through debate	11) Peer group/team (Collaborative) teaching
5) The case method	12) Work-based learning
6) Brainstorming	13) Self-learning
7) Teaching workshops	14) Creative assignments
	15) Pre-lecture based learning
Technology-Oriented Teaching Methodologies:	16) Curiosity-driven learning
22) Online courses (Video lectures)	17) Z to A approach
23) Teaching support via websites and social media	18) Block schedule
24) Learning/teaching method based on audio library	19) Patent base oriented syllabus
25) Web-based engineering experiments	20) Teaching by following the standardization process
26) Teaching through games (Gamification)	21) Teaching fundamentals through vocation-related examples

Student-Oriented Teaching Methodologies

3.2.1. Student-centered education

In student-centered education students choose what they will learn, how they will learn, and how they will assess their own learning. In this way students become more responsible for own learning path, and learning process becomes zestful. This teaching methodology has been shown as effective in higher education (Brown Wright, 2011). In such a manner, students become more motivated and put disciplinary information into wider context. Besides acquiring knowledge about the subject, students obtain lifelong learning skills that will help them to be more prepared to the engineering problems in the future and competitive job market. In this scenario, a teacher becomes a facilitator who should show to a student how to learn a specific subject most effectively.

3.2.2. Flipped or inverted classroom

Flipped or inverted classroom is a pedagogical approach in which standard roles in the classroom are reversed: students take over the role of the lecturer while the lecturer is sitting in the classroom and listening to student lectures (Tucker, 2012). Students are provided instructions and assignments in advance in the form of reading assignments or video lectures and they prepare suitable presentation material for the lecturer and fellow students.

Flipped classroom is suitable for implementation of a small part of lectures or tutorial sessions. It is useful for students as it provides them with an opportunity to present in front of the audience and thus improve their presentation skills as well. Many studies show that significant percentage of students have a strong fear and discomfort when presenting publicly and usually, practice helps to overcome these barriers. Thus it is very important to expose students to public presentations much earlier than, e.g., for their bachelor thesis defense. Methodologically, it is recommended that the course lecturer covers fundamental topics using a standard lecturing approach, and then use reverse classroom for extensions of the fundamental material.

3.2.3. Teaching through student competitions

Teaching through student competitions is a teaching methodology similar to research-related teaching or project-based learning, the major difference being that the class projects are designed so that students compete among each other, either individually or in small groups. One possible option to set up the course competition is that, during the project realization phase of the course, all students (or groups) realize the same project. In other words, the course will have several teams working independently on the same problem, so that the final results are comparable and so that the course instructor is able to establish a clear and objective difference in the performance of different students/teams. This methodology is usually very motivating for students and it is very useful emulation of real-world problem solving, where the success of problem solution depends not only on how well one solves the problem, but also from the quality of other available solutions.

3.2.4. Teaching through debate

Teaching through a debate is very similar to the methodology of teaching through a competition with the same project task, the basic difference is that competing groups review the project solution for each other and discuss a solution. After the completion of the review process, a debate is organized by a lecturer, where student groups present arguments for their suggested solutions. This learning technique contributes to improving the argumentation skills, teamwork among students, and developing the ability to accept different opinions (Mumtaz & Latif, 2017).

3.2.5. The case method

The case method is a participatory, discussion-based way of learning where students are presented a real-world problem (a case) and placed in the role of a decision maker that needs to provide a solution to the presented problem, addressing all potential tradeoffs. Through whole-class discussions, students are expected to collaboratively parse through and sort out the given information, draw conclusions by invoking relevant theory, and finally present possible solutions with pros and cons of each (Bruner, 2003). The real-world nature of a case is expected to bring interest and invoke application of abstract concepts and theory in practice, which promotes contextual learning and long-term retention. Further, this way of learning is extremely effective: it employs active learning and involves self-discovery, thus developing in students the confidence that they will be able to solve a similar problem in the future (outside of the “classroom walls”). Finally, through debates that arise in analysing the posed problem students develop the ability to see a problem from different perspectives, and also to justify their proposed solutions. Hence, they gain skills in critical thinking, effective communication, and decision making, which are important for any engineering profession, where tradeoff challenges often arise and hence it is important to be able to address them properly and with sound justifications.

3.2.6. Brainstorming

Brainstorming (Patil & Prasad, 2016) is a technique intended to generate a large number of ideas. The technique was devised by Alex Faickney Osborn and was widely used by business managers to generate ideas and to find out creative ways of resolving management crises (Osborn, 1953). Currently this technique is extensively used for teaching/learning. Brainstorming involves the use of different techniques like problem solving, model making and simplification. There are two types of brainstorming (based on the number of participants): individual and group brainstorming. The individual brainstorming involves allotting a task theme and asking people to work on it individually. The individual ideas are then consolidated. On the other hand, in group brainstorming, groups consisting of several participants are formed for a said task.

3.2.7. Teaching workshops

Teaching workshops allow instructors to create a student-centered atmosphere and employ active learning. Workshops can help students learn to collaborate and communicate (Mommers, Schellings, & Beijaard, 2015). Eventually, the group process itself can become a learning tool. Participating in classes can help students to learn: successful collaboration and effective task sharing techniques, inter-personal skills, listening skills, and verbal communication skills. The synergy that can result from group discussions often leads to a higher quality solution to a problem than an individual one. Workshop has to be carefully thought out, with clear learning objectives. Assignments and readings should be provided to the students in advance. Throughout the workshop activities should vary, as well as the pace of presentations, in order to ensure participants’ attention and interaction. In the end, the workshop should be summarized and feedback taken from participants. When possible, the workshops should promote interdisciplinarity, allow for looking at the same problem from other perspectives, being more constructive than competitive.

Activity-Oriented Teaching Methodologies

3.2.8. Active learning

Active learning enables students to become much more engaged with their own learning. Active learning does not assume a fixed set of activities, but offers another approach to the teaching process. It includes any activity that encourages students to take an active, engaged part in the learning process within the classroom, such as: group discussions, student presentations, experiments, quizzes, problem-solving, roleplay, etc. In the labs, students can take an active role being responsible for a part of the processes which demand combining their knowledge, identification and realization of the tasks to be achieved (e.g. setting the stage for the signal acquisition, creating processing pipelines, etc) (Guthrie & Carlin, 2004). By becoming active participants in the classroom, students build knowledge through their own experiences. Active learning can help students achieve deeper understanding of a topic than by passively listening to a lecturer or reading textbooks. For a lecturer active learning provides more opportunities to interact with students.

3.2.9. Research-related teaching

Research-Related Teaching (RRT) refers to an educational approach where students learn through research: they experience learning, acquire knowledge, and develop skills and competences by doing research themselves. The ideal start for this type of courses is in final years of the bachelor level, while master level courses are frequently the best position for an RRT-type course, especially if the course is elective (not obligatory) and can be selected by students with research-oriented interests and skills. RRT might typically rely on a predefined set of research projects, which are designed for every realization of the course (frequently, these courses are entitled: “Selected topics in…”). The lecturer provides several introductory lectures, which will bring the topics of research project closer to students so that they have sufficient background to select one of the topics that fits best to their interests. After this introductory stage, students work independently on the realization of their individual or small-group projects. Usually, the student starts with reading assignments, where the requirement is reading and understanding of a selection of very recent research papers closely related to the individual project topic. In parallel with reading and understanding, the student is having weekly discussion sessions with the lecturer about what has been read. The student then proceeds to implementation, which typically assumes attempts to recreate the results obtained in the research papers being analyzed. This is not only important for a student as an opportunity to practice implementation skills, but is fundamental as a reference to future work on a project where the student will be asked to suggest/devise improvements of the proposed project and test the proposed solutions against the state of the art. In the case of very successful and most ambitious projects, the student will be advised to prepare a conference paper, possibly integrated as the course project extension and additional work towards bachelor or master thesis. Thus, RRT-type of courses are typically suitable as an introduction to bachelor or master thesis work, where the student uses this course to establish strong fundaments and initial results for future work on her/his thesis.

3.2.10. Project-based learning

Project or Problem-Based learning (Bell, 2010) refers to a teaching methodology similar to RRT, with the only difference being in the focus, which is in this case shifted to development rather than research itself. Such a course is suitable for final BSc year as well as an MSc course. It can be similarly designed as RRT courses: it first passes through the introductory stage where fundamentals are presented to students, after which the students pass to the development stage. In the development stage, a collection of development projects is presented to students and they select to work on these projects either individually or in small groups. The goal of the development project is e.g., a working prototype, a source code efficiently executing a given algorithm, a piece of programmed hardware (embedded system, DSP, FPGA), etc. Ideally, these courses are organized in collaboration with the industrial ecosystem, where experts from industry propose and oversee the development of projects.

3.2.11. Multi-subject project-based learning

The method is a variant of project-based learning or research-related teaching. The project assignment is associated with more than one subject (Schaller & Hadgraft, 2013).
The challenges of this approach are: the need for excellent communication and mutual understanding of teachers of different subjects, the choice of appropriate project assignment, the decision about the appropriate weight of the project assignment when calculating the overall grade of each of the subjects, increased need of consultation hours.
The expected benefits of this approach are: all benefits of the project-based and problem-based learning or research-related teaching, students are expected to perceive certain topics from different points of view at the same time, students are encouraged to see a broader picture of the area of their study programme or module instead of learning in “subject by subject”, or “topic by topic” way.

3.2.12. Peer group/team teaching (Collaborative teaching)

This methodology is related to Research-Related Teaching and Project-Based Learning, although many studies use this name for broader methodology. One of the most visible approaches to peer learning comes out of cognitive psychology, and is applied within a "mainstream" educational framework. "Peer learning is an educational practice in which students interact with other students to attain educational goals." (Patil & Prasad, 2016) The peer group (team) learning practice is popularly called cooperative or collaborative learning. It involves educators working in pairs to lead, instruct and mentor groups of students (Jayashree, 2017).

3.2.13. Work-based learning

A work-based learning (WBL) programme can be defined as a process for recognising, creating and applying knowledge through, for and at work which forms part (credits) or all of a higher education qualification (Fry, Ketteridge, & Marshall, 2008). WBL is seen by the majority of university engineering departments as learning *for* work. Typically, this includes WBL undertaken by full-time undergraduate students as part of their degree course in the form of sandwich placements and work experience modules. There are challenges for university lecturers in structuring WBL into a taught degree programme, and in its assessment as part of the overall degree assessment. Ideally a placement learning contract is established against a competence assessment framework and in some cases the placement is credit bearing. The period of work experience can vary from a few months to a whole year.
The vast majority of students will say that WBL activity has improved their generic and personal transferable skills (e.g. multi-tasking, working under pressure, communication, timekeeping, interpersonal and reflective skills). They also have the chance to use the theory and apply it to real-life projects. Lecturers report that WBL is important in improving student motivation, the generic skill set and specific engineering skills, and this is recognised by employers when it comes to graduation.
Key stages in a successful work placement scheme include:

- Finding the placement;
- Working in partnership – the company, the university, the student;
- Health and safety;
- Preparing the student (visiting lectures by industrialist recruitment specialists and presentations by career staff and students returning from industry can all be useful);
- Maintaining contact with the student (in the workplace, students are best supported by a visit from an academic member of staff).

Assessment – students gain most benefit from the placement if the formal assessment process is clear. However, the novel and innovative nature of WBL requires that nontraditional means are found for assessing it. Students need to be conscious of their development and to be encouraged to assess their own progress. This may be assessed via a portfolio or personal development diary. Many students in industry carry out project work and the project report may form a part of the assessment.

3.2.14. Self-learning

Self-learning or self-directed learning is learning for the sake of one's own knowledge by conducting research, reading articles and books, or employing other platforms. According to the conducted studies, it was concluded that students had a strong desire for learning, and they were expected to complete the undergraduate program and gain work experience, while self-management had the lowest rating, indicating that the students had issues with planning and time management of their studies (Taneja, Safapour, & Kermanshachi, 2018). Self-learning is an inherent part of many other methodologies, although in some studies it is presented as separated one.

One of advantages of the self-learning teaching method is related to opportunity to select one's field of study and studying at her/his own place, according to individual schedules (Taneja, Safapour, & Kermanshachi, 2018). Students have the privilege of assessing their own performance, enabling them to rate themselves, figure out where they went wrong, and take the required steps to rectify their errors. In some studies, the learner using this method is termed as a thinker and creator of knowledge rather than as a passive individual who is dependent on the knowledge of others. The importance of self-directed learning has been put in three contexts: (1) self-directed learning in the workplace, (2) self-directed learning for personal effectiveness and satisfaction, and (3) self-directed learning in formal learning settings. It was observed that with the application of the self-directed learning approach, students learn successfully and enjoy a feeling of satisfaction with both the course and the teaching approach (Taneja, Safapour, & Kermanshachi, 2018).

3.2.15. Creative assignments

Most of the teaching methods require a greater amount of effort on the teacher's part. This is not the case with the assignments where significant work is needed on the students' part. On the other hand, in this way, the assignments help students to learn something on their own. This teaching method is very appropriate for sciences and engineering disciplines. In teaching activities there are very often practices that students show more interest in some particular items included into the subject; therefore this method may encourages students' curiosity and creativity. Namely, they are supposed to create their own assignments according to the interest in some particular area and topics related to the course content. In this manner they will appointed the task to themselves that will required additional investigations, introduction with available literature, research, and acquiring adequate solution. Additionally, students may present the achieved results by using various creative approaches, as sketches, illustration, audio or video records, as well as the standard tools as report, presentation and similar tools, which could be a possible way for the knowledge assessment. More details about this approach one can find in (Patil & Prasad, 2016).

3.2.16. Pre-lecture based learning

Pre-lecture resources (Seery, 2010) are any activity a student might do in preparation for lecture. This could take the form of reading a textbook extract or Word document, listening to a podcast, performing an online activity or completing a quiz. However, a key aspect is that the pre-lecture activity is integrated into the module design and into the lecture itself, so that it is attributed a sense of value by student and lecturer. The concept of pre-lecture activity is underlined by cognitive load theory, which describes how learners acquire and retain new information. The load, or mental effort has three components, and capacity to process the load is limited by working memory and enhanced by level or prior knowledge. The three components are intrinsic load – the processing of unfamiliar new material and terminology; extrinsic load – the sifting out of pertinent information from information provided; and germane load – the acquisition and integration of new knowledge and storage into long term memory. Pre-lecture resources aim to reduce intrinsic load by introducing some terminology or concepts prior to a lecture, so that students can become familiar with these and allow for working

memory in the lecture to concentrate on integrating these terms/concepts into long term memory (germane load).
The purpose is to reduce the load associated with the lecture itself, so the resource might introduce some key terms or ideas, ask students to review something before the lecture (which will subsequently be discussed in the lecture) and/or structure a review of some key terms from a previous lecture that will be useful for the forthcoming lecture.

3.2.17. Curiosity-driven learning

Curiosity is inherent to human beings. Children learn through interacting with the world, examining the surrounding, making models, testing and revising them. This is the main driving force of the continuous learning cycle. In a way it is even similar to the scientific method, where observation of a phenomenon is followed by formulation of a hypothesis and its testing. The goal of this approach is to revive and stimulate this naturally existing behavior. This will enable students to explore a problem domain by making their own observations, as well as models and concepts capable of explaining these observations. These models and concepts are then tested on new data and refined and revised. The teacher's role is to stimulate the curiosity embedded by proposing the initial themes and problems and, later on, by presenting the current state of the subject. This approach is appropriate for courses in the later years of the first cycle or courses in the second cycle.

3.2.18. Z to A approach

Z to A approach (Patil & Prasad, 2016) attempts to explain the application part of a particular concept first. The teacher should explain the application of a particular concept first prior to teaching theorems, definitions etc. about the concept. For example, in the Electronic Communication subject, while teaching the radar topic, first the practical applications of radar can be explained, which will create interest amongst students, and then the theory behind it should be explained.

3.2.19. Block schedule

The term 'block schedule' refers to taking one class at a time, all day, every day, until all of the material relative to a course (or a section of a course) is covered. RT-RK has been using this methodology for more than 15 years at the 4th year BSc and 5th year (MSc) studies in the study module Computer engineering and communications, part of the Computing and Control Engineering study programme.
Block Schedule methodology consists of courses organized in 3-week (or 4-week, depending on the course) blocks in which students concentrate on a single subject during that period – also known as *One-course-at-a-time* (OCAAT) teaching methodology. There are several variants of the block organization, e.g. 1-2 weeks of lectures combined with laboratory computer exercises (lectures happen during the morning, while lab sessions happen during the afternoon, every weekday); the remaining time is allocated to the project task which students individually complete and present on the last day of the block. Theoretical exam is organized once during the block (near its end) and later in the official exam periods.
There are many advantages which have been discovered during the years of application:

- Students concentrate on a single subject and especially, during the work on the project, there are no distractions while solving the given problem – in this way a major obstacle to classical study programme (focus split to many different topics) is overcome;
- This is an example of the project-based learning since projects are in the focus and 50% or more time is dedicated to practical work;
- Practical skills of students are significantly increased at the end of a block;
- In the last semester of the studies, blocks of courses end earlier than the semester ends (mostly in April), which leaves 1-2 months of the semester for bachelor thesis work, which is also done without distractions (for students which complete all of their exams on time) – this increases the rate of students who graduate before summer.

Still, there are some disadvantages, e.g. the lack of time for the knowledge of a particular subject to be absorbed into long-term memory, which is better done with a course that lasts the entire semester, than within the block. This is why this methodology may not be convenient for lower years of study, but it is quite convenient for higher years, when the focus is on practical skills and getting ready for the employment.

3.2.20. Patent base oriented syllabus

PBOS should represent any type of teaching methodology that significantly utilizes the knowledge contained in patent applications and corresponding databases from some specific field, and which introduces students to patents as one of the main source of literature throughout the course (Bekkers & Bombaerts, 2017). Such an approach requires careful preselection of patents that will cover the most of the planned course topics, but also a detailed dissection of their content and main contributions. The described approach should bring the audience closer to real-life situations and enable easier development of problem solving skills. PBOS makes students more familiar with intellectual property protection and national and international patent office regulations, however, this should only be regarded as a side effect and not as the main goal of PBOS methodology. The students should be also encouraged to make own patent research, through the additional tasks or projects during the course, with emphasis on critical thinking and analysis of advantages and disadvantages of proposed solutions. At the end of the course, students should also be introduced to several selected case studies in which they could analyze competing patent applications covering the course topics they have already learned and discuss possible motivation for formal protection of proposed solutions, if possible with the guided help of patent office examiner in the role of the guest lecturer.

3.2.21. Teaching by following the standardization process (Learning by experiments with open hardware and software testbed)

This novel learning methodology follows the latest concepts and advances in communication technologies and standards. This approach is based on next-generation Internet standards currently being developed, which allows following the standardization process and learning from it (Watteyne, Tuset-Peiro, Vilajosana, Pollin, & Krishnamachari, 2017). The availability of open source implementations provides the opportunity to discover the inner details of embedded operating systems (concurrency, task switching, memory footprint) and low-level peripherals (timers, communication buses, radio transceivers). Using the open-software and open-hardware platforms empowers students with a valuable set of competences, including topics related to computer networking (Medium Access Control operation, IPv6 networking), embedded systems (process scheduling, concurrency) and wireless communications (multi-path propagation, interference effects), as well as application requirements for the next generation networks and systems.

3.2.22. Teaching fundamentals through vocation-related examples

Most engineering curricula at universities participating in the BENEFIT project are designed so that the first couple of semesters (3-4) are almost fully dedicated to studying fundamentals (e.g., mathematics, physics, etc.) needed as a background for vocation related courses that appear later on. Typically, these fundamentals-oriented courses (e.g., at UNS, Mathematics 1-4, Physics) carry a high number of ESPB and often are regarded among students as difficult and demanding, consuming a relatively high percent of total study time compared to vocation-related courses. In addition to that, even after successful completion of a fundamentals-related course, students appear to be unable to apply the learned concepts (or simply recognize them) when they meet these concepts in a different form in a vocation-related course (e.g., eigenvalues as modes of a linear dynamical system or of a channel matrix, controllability and observability of a linear system through range and null space, infinite series in pulse shaping (in the presence of phase offset), conditional probability (for bit error rate computation), maximum likelihood criteria (for optimal message detection regions), differential and integral calculus etc.). To increase the efficiency of a curriculum in this respect, a simple yet effective solution could be implemented: to inject auditory exercise sessions or lecture sessions with carefully designed mini-lectures that would consist of illustrative examples of the taught concepts in the respective vocation areas (depending on a specific course, these could be given by the course instructors or by the faculty engaged in teaching vocation-related courses). The benefits of this approach would be manifold. First, once an abstract concept/result is brought to life by a specific illustration or application in the relevant domain of study, students will more easily appreciate its importance and will be more willing to absorb it (in spite of its potential “abstractness” and level of difficulty). Second, this will immediately fill in the gap between the fundamental and vocation-related courses, as background concepts will easily be invoked and applied when needed in the future, without unnecessary recapitulations that often waste time. This could in turn leave space for more advanced or up-to-date topics during lectures. Finally, a step like this towards closing the loop around theory and practice will give much more confidence to students, and their perception of the curriculum would shift from “too theoretical” to realizing that they have a competitive advantage from understanding things at a fundamental level.

Technology-oriented teaching methodologies

3.2.23. Online courses (Video lectures)

Online course is a set of prerecorded course material in the form of video lectures. It can be realized either in advance and without students (in a controlled environment) or it can be created during a semester in a real-world classroom environment. If targeting a reasonable quality of online course, technical realization of video lectures is a very important issue. In other words, high-quality video editing is required where simultaneous view of the lecturer as well as the material being presented, either in the form of slides or writeup on the whiteboard, is needed. In addition, the quality of audio recording is an important issue. If the video material is professionally designed and lecture content is in English and well designed and prepared, then it is reasonable to make the material openly available, which is current world-wide trend usually termed Massive Open Online Courses (MOOC) (Jordan, 2014).

3.2.24. Teaching support via websites and social media

This can be seen as the technological extension of the traditional teaching methodologies and represents connections of lecturer and students into an education community (Moran, Seaman, & Tinti-Kane, 2011). Students and teachers are all connected through social media and the Web. This allows students and teachers to maintain communication about classroom events and assignments. Teachers can use these technologies to create a homework blog, a classroom website or student blogs. Another innovative use of social media and the Web is the creation of education-related boards (Zaidieh, 2012). These boards can inspire students to discover and do what they love. It sparks student’s creativity, gets students trying new things, and allows them to be themselves. Students home feed is the center of boards, where student will find ideas, or pins, that help to them see a world of creativity and possibility all around them. Each of these technologies opens up the classroom, encourages interaction and facilitates communication within the community, among students as well as between students and teachers.

3.2.25. Learning/teaching method based on audio library

The scope and volume of course material has to represent a balance between the available time and ever-increasing knowledge corpus, particularly in domains such as engineering. However, new technologies can be employed to offer useful alternative modes of receiving lectures. In particular, audio-editions of handbooks and other course material enables students to receive lectures even while resting, walking or traveling. Even during active learning, it can be helpful to focus on a visual illustration while listening to the corresponding text delivered by voice instead of reading it. This can also be useful for slow readers and help them maintain their tempo, and also makes textual material more accessible to a range of people with disabilities (the visually impaired, persons with reading disorders or those unable to handle books due to physical limitations). On the other hand, production of audio-editions based on voices of actual human speakers is costly and time-consuming, and it also requires a certain technical effort. Audio-editions based on high-quality text-to-speech synthesis offer a very efficient alternative, and can be produced very quickly and in a fully automated way. The only limitation of this technology is its inability to appropriately convert items other than plain text (formulas, figures or tables) into speech. At the moment the solution is in providing a textual description or interpretation of each such element in the text. A very high quality text-to-speech technology has already been developed for the regional languages of Western Balkan countries, which participate on this project, by the University of Novi Sad, one of the project partners from Serbia. This technology has already been exploited to create the Central Audio Library of UNS, which contains audio-resources that have been created so far and provides an efficient interface for both lecturers and students (Delić, et al., 2019).

3.2.26. Web-based engineering experiments

One vital aspect of engineering is the laboratory and practical work necessary to give engineering students a taste of real situations, measurement and instrumentation, with all the attendant problems. The concept of web-based experiments (Magoha, 2002) has revolutionised engineering laboratory and practical work. The idea is that students become able to perform real experiments in real time on real equipment, but over the Internet. Internet-based learning facilities can be developed to demonstrate all aspects of teaching engineering. One such development is a remote-controlled laboratory, which provide browser based access to computer applications and desktops (virtual and physical). The Remote Desktop web client allows students and teachers too quickly and easily access to infrastructure in laboratory through a web browser via the internet. They'll be able to interact with remote applications or desktops like they would with a local PC no matter where they are in that moment. The aim of implementing such solutions (ThinFinity, Free RDP Windows, Ericom AccessNow, etc.) is to enable students to acquire knowledge and master skills related to the computer networks and software engineering courses (there is a group of general education courses as well as a few elective courses belonging to other study programs in the Faculty of technical sciences in Novi Sad). Students acquire knowledge in network protocols, i.e. the communications rules in computer networks, and network devices which enable secure connection and proper work of computer networks. They remotely work in real conditions: they configure network devices to generate optimum network performance, control and verify the results.

3.2.27. Teaching through games (Gamification)

This methodology belongs to Teaching through Student Competitions methodology, or it can be considered to be a part of it, but it is defined here in more detail.
Students generally like games and want to play them more and more. Traditional methods dictate study and games to be separate but the fact remains that the students are more interested in playing games rather than sitting and studying. Thus, it is logical to combine these two aspects and solve the problem. The learning by means of games would help the students keep their interest in the subject. With this methodology, the learning process would continue almost throughout the day without the student getting tired or bored of studying. Actually, students learn without having to engage in the traditional learning process – they practically learn without even realizing it. Competition and scoring motivate and involve the students, and although scoring doesn't affect the student learning, it motivates them to try hard. Huotari and Hamari defined gamification as a process of enhancing services with motivational affordances to invoke gameplay experiences and further behavioral outcomes (Taneja, Safapour, & Kermanshachi, 2018). The main motivation is to improve the involvement of individuals and increase their interest, engagement, and efficiency (Taneja, Safapour, & Kermanshachi, 2018).
The different forms of games that can be used are:

- Word game/cross word puzzle: Teacher can make two groups in class, like a group of boys and a group of girls. Then a competition can be started amongst two groups to write maximum words, definition, terminology etc. pertaining to a particular subject.
- Role play: A complicated concept can be simplified with the help of role play. Science and engineering courses have practicals, which simplify understanding theoretical concepts.

However, for each and every theory, practicals are not possible. So, in such a situation, role play, an educational drama helps a lot. Here several volunteers as per requirement are asked to play the game where each volunteer student will play a certain role. For example in the concept of working of microprocessors, one volunteer will play the role of accumulator; another will play the role of register, ALU, clock etc.

According to the literature studies, there are elements within the design of multiple online role-playing games which foster intrinsic motivation while requiring players to think, plan, and act critically and strategically. Gamification increases motivation for learning which requires less previously acquired knowledge and, as a tool combined with other methodology, increases learning outcomes. It is not, however, fully dependable for learning outcomes.

Previous studies show that emerging technologies, such as games, must be goal directed, competitive, and designed within a framework of choices and feedback to enable teachers and students to monitor learning progress. Playing and designing games can contribute to active, engaging, and authentic educational experiences (Lillejord, Børte, Nesje, & Ruud, 2018).

Table 2. *Selection of proposed teaching methodologies to be adopted in 62 novel/enhanced courses*

	Teaching Methodology	**BSc**	**MSc**	**BSc+MSc**
1	10) Project-based learning (Action-Oriented)	63 %	73 %	66 %
2	8) Active learning (AO)	38 %	59 %	45 %
3	9) Research-related teaching (AO)	25 %	64 %	39 %
4	5) The case method (Student-Oriented)	10 %	36 %	19 %
5	23) Teaching support via websites and social media (Technology-Or.)	15 %	18 %	16 %
6	17) Z to A approach (AO)	23 %	5 %	16 %
7	7) Teaching workshops (SO)	20 %	5 %	15 %
8	2) Flipped or inverted classroom (SO)	13 %	9 %	11 %
9	22) Online courses (Video lectures) (TO)	13 %	5 %	10 %
10	14) Creative assignments (AO)	8 %	14 %	10 %
11	6) Brainstorming (SO)	10 %	9 %	10 %
12	11) Peer group/team teaching (Collaborative teaching) (AO)	10 %	5 %	8 %
13	15) Pre-lecture based learning (AO)	13 %	0 %	8 %
14	3) Teaching through student competitions (SO)	8 %	0 %	5 %
15	24) Learning/teaching method based on audio library (TO)	8 %	0 %	5 %
16	1) Student-centered education (SO)	3 %	5 %	3 %
17	12) Work-based learning (AO)	5 %	0 %	3 %
18	13) Self-learning (AO)	5 %	0 %	3 %
19	4) Teaching through debate (SO)	0 %	5 %	2 %
20	16) Curiosity-driven learning (AO)	3 %	0 %	2 %
21	20) Teaching by following the standardization process (AO)	3 %	0 %	2 %
22	19) Patent base oriented syllabus (AO)	0 %	0 %	0 %
23	21) Teaching fundamentals through vocation-related examples (AO)	0 %	0 %	0 %
24	26) Teaching through games (Gamification) (TO)	0 %	0 %	0 %
25	25) Web-based engineering experiments (TO)	0 %	0 %	0 %
26	18) Block schedule (AO)	0 %	0 %	0 %
27	Other methodologies	8 %	0 %	5 %

4. Overview of Platforms and Tools used for Teaching

Several interactive and multimedia, e-learning and online learning tools are presented in this section.

Interactive electronics tutorial

A tutorial is more interactive and specific than a book or a lecture and seeks to teach by example and supply the information to complete a certain task. Depending on the context, a tutorial can take one of many forms, ranging from a set of instructions provided to complete a task to an interactive problem solving session.

Interactive electronics tutorial (Patil & Prasad, 2016), (Trujillo-Aguilera, Sotorrio Ruiz, Pozo Ruz, Vegas, & Javier, 2015) helps the lecturers in their explanations. The tutorial can be a useful tool that enables usage of several multimedia computing applications in a virtual space (like internet) for the presentations. Furthermore, this tutorial contributes to an increase of the student self-learning, since students can use the tutorial before and even after the classroom explanations. In any case, the tutorial motivates students to make a self-learning effort and holds the students responsible for their self-learning. Besides, the tutorial fosters the knowledge construction and, finally, allows students to have a control of the content and activities.

Multimedia

Multimedia (Patil & Prasad, 2016) (Magoha, 2002) is a combination of audio and visual materials. It is used to enhance communication and enrich presentation. In multimedia, subject matter and exercises are selected according to an optimised concept or put together in an ad hoc way by the lecturer specifically to achieve a given teaching objective. Those who wish can use available information in different formats, such as images, text, animation and videos.
Teachers can use audio-visual aid to show video lectures, animations, etc. This method imparts knowledge of renowned personalities in the concerned subjects to students by playing their lectures (Patil & Prasad, 2016).

Simulation software

Simulation software is software designed to provide a realistic imitation of the controls and operation of a real (complex) system. Simulators play a highly important role in the curriculum of electronics engineering. Different simulators such as microprocessor simulator, circuit simulators or simulator for modeling designs, devices and processes (e.g., COMSOL) can effectively be used within a curriculum. Simulators give in-depth working knowledge as well as system design level knowledge to the students. Simulation modeling solves real-world problems safely and efficiently. It provides an important method of analysis which is easily verified, communicated, and understood. Across industries and disciplines, simulation modeling provides valuable solutions by giving clear insights into complex systems. For instance, a computer-aided design (CAD) software-based engineering drawing course can have positive effects on developing engineering students' spatial visualisation skills.

Virtual/Augmented Reality

Virtual reality (Magoha, 2002) (Lillejord, Børte, Nesje, & Ruud, 2018), with its extension of televirtuality, has revolutionised engineering education training. It offers users the possibility to create a representation of their educational models and to move about within virtual space. The 3D visualisation created with the help of virtual reality can provide a picture, which is both comprehensible and accessible for a nonspecialist user. Augmented reality is a promising emerging technology with educational potential as it projects digital material onto real-world objects, enhances and expands students' learning experiences and facilitates collaboration and student active learning (Lillejord, Børte, Nesje, & Ruud, 2018).

E-learning tool

Terminology and use cases

Distance learning/education concept enables students' remote access to (1) ongoing activities and/or (2) stored materials. It therefore includes online learning, and it is equivalent to other terms such as distributed learning, e-learning, virtual classroom etc. (en.wikipedia.org/wiki/Distance_education, n.d.)

Distance education technologies are divided into two modes of delivery: synchronous and asynchronous learning.

- Synchronous learning resembles traditional classroom, since the content is delivered to all "attendees" at the same time. It involves real-time communication technology for telepresence (telephone/VoIP, web/video conferencing) or content broadcasting (e.g. educational television, instructional television, direct-broadcast satellite (DBS), internet radio, live streaming):
    - Web conferencing software helps to facilitate meetings in distance learning courses and usually contain additional interaction tools such as text chat, polls, hand raising, emoticons etc.
    - Telepresence robots (Kubi, Double Robot) are being used to enhance "presence and interaction" of remote students.
- In asynchronous learning, participants access course materials flexibly on their own schedules. Examples of asynchronous delivery technology are message board forums, e-mail, video and audio recordings, print materials, voicemail, and fax. (Lever-Duffy & McDonald, March 2007).

One of the most significant issues of distance education is the limited interaction between learner and teacher. Therefore, various strategies, techniques, and procedures are developed to increase the amount and quality of this interaction.

Distance learning can also use interactive radio instruction (IRI), interactive audio instruction (IAI), online virtual worlds, digital games, webinars, and webcasts, all of which are referred to as e-Learning. (Burns, 2011)

- Interactive radio instruction (IRI) is a distance education system that combines radio broadcasts with active learning to improve educational quality and teaching practices. (http://blogs.worldbank.org/edutech/iri, n.d.)
- Interactive Audio Instruction (IAI) is a distance learning technology that can deliver low-cost, culturally appropriate education via radio or mobile audio technology. (World Bank Group, February 2015)
- An example of virtual world such as Second Life, "a free 3D virtual world where users can create, connect, and chat with others from around the world using voice and text." (https://secondlife.com/, n.d.)

Internet forums, online discussion groups and online learning communities can contribute to an efficient distance education experience.

The widespread use of computers and the internet have made distance learning easier and faster, and today many universities offer online courses. There are also „virtual schools/universities“ that deliver full curricula online.

Barriers to effective distance education include obstacles such as domestic distractions and unreliable technology, (Östlund, n.d.) as well as students' programme costs, lack of adequate contact with teachers and support services, and a need for more experience. (Galusha, n.d.)

Blended learning combines traditional place-based classroom methods (campus-based learning) with online interaction (distance learning), i.e. "computer-mediated activities regarding content and delivery“. (https://en.wikipedia.org/wiki/Blended_learning, n.d.). Many open universities use a blend of technologies and a blend of learning modalities (face-to-face, distance, and hybrid) all under the joint term of "distance learning".

E-learning components

According to (https://en.wikipedia.org/wiki/Educational_technology, n.d.), educational technology among others covers the following aspects:

- technological tools and media that assist in the communication of knowledge, its development and exchange, e.g. massive online courses,
- learning management systems (LMS), such as tools for student and curriculum management, and education management information systems (EMIS).

Both listed aspects of education technology are necessary to develop learning platform for e-course delivery, such as Moodle or Open edX.

A Learning Management System (LMS) can be analyzed by sorting the features into four group: tools for distribution, tools for communication, tools for interaction and tools for course administration. (Garrote Jurado, 2014)

Application of “technological tools and media” is related to the particular usage scenario. In that sense we can identify several types of interactions:

1) telepresence,
2) online material access,
3) online collaboration, and
4) extended classroom interaction.

The last category can be considered as extension of telepresence interactions, since classroom environment allows application of real-word gadgets, such as Acer Classroom Manager/TechSmart: “… 4-colour LED light, embedded on the cover of the laptop, that can be used to track students’ status and progress and to make classroom participation more dynamic and visual”

The listed interaction types correspond well with e-learning components:

1a) A virtual classroom is an e-learning event where an instructor delivers a lecture remotely and in real time to a group of learners using a combination of materials (e.g. PowerPoint slides, audio or video materials);
1b) E-tutoring, e-coaching and e-mentoring provide individual support and feedback to learners through online tools and facilitation techniques;
2) E-learning content (simple learning resources, interactive e-lessons, electronic simulations, and job aids;
3) Collaborative learning: collaborative activities range from discussions and knowledge-sharing to working together on a common project. Social software, such as chats, discussion forums and blogs, are used for online collaboration among learners;

identified in (E-learning methodologies - A guide for designing and developing e-learning courses, 2011). This guide was developed in the FAO UN project, funded by the government of Germany, with the purpose to provide detailed guidance on designing and developing an e-learning course.

Telepresence tools

ICT is considered as essential tool for bridging "distance" gap in interaction or delivery of multimedia content.

- **M-learning** or mobile learning relies on portable technologies (handheld computers, MP3 players, notebooks, mobile phones and tablets). It enables learner mobility and instantaneous interaction/feedback (e.g. audience response). (https://en.wikipedia.org/wiki/M-learning, n.d.)
- **Screencasting** is a digital recording of computer screen output, also known as a video screen capture, often containing audio narration. (https://en.wikipedia.org/wiki/Screencast, n.d.) It facilitates the presenter to demonstrate interaction with software tools. For distant learners it provides essential insight into lecture activities.
- **Webcasting** enables creation of virtual classrooms and virtual learning.

Listed functionalities are supported by a wide range of video conferencing tools, such as Google Handouts, (Cisco) WebEx Meetings, Zoom Meetings, Skype (for Business) etc.

In addition to computers and communication networks (internet), tools such as dedicated robots are being developed in order to improve "telepresence":

- Kubi Virtual Telepresence Robot (https://www.revolverobotics.com, n.d.): "The Kubi, while a stationary robot, offers the ability to pan up to 300 degrees and to tilt (up or down) up to 45 degrees. The Kubi will work with any tablet and any video conferencing platform to make video calls simpler and more engaging in business, telemedicine, and education." (https://telepresencerobots.com/robots/kubi, n.d.)
- Double Robot (https://www.doublerobotics.com/, n.d.): is traversing common obstacles in an office or classroom setting, such as cords, bumps, or a change in threshold. It uses "Always-on Floor View" for increased spatial awareness and time saving: no need to switch between camera views.

Collaborative learning tools

Blog is a discussion or informational website published on the World Wide Web consisting of discrete, often informal diary-style text entries (posts). (https://en.wikipedia.org/wiki/Blog, n.d.)

- A World Bank Blog on ICT use in Education (http://blogs.worldbank.org/edutech/, n.d.), is an example of how dedicated and relevant blog content can be.

Collaborative software or **groupware** is application software designed to help people involved in a common task to achieve their goals. [https://en.wikipedia.org/wiki/Collaborative_software]

- According to (https://teach.com/what/teachers-know/teaching-methods/?_ga=2.73346323.106813785.1551566905-2102080725.1551566905, 2019) G Suite (Gmail, Docs, Drive, and Calendar) belongs to this category.

The **gamification** of learning is an educational approach to motivate students to learn by using video game design and game elements in learning environments. (Kapp, 2012)

- 3D GameLab (http://3dgamelab.com/, n.d.) by Rezzly is a quest-based learning platform that teachers and students can use to create and play leveled questions. Students can work toward subject mastery by earning points and other rewards. Rezzly (https://www.rezzly.com/, n.d.)

applies game thinking and mechanics for a new kind of learning platform. As players complete quests, they “level up” to reach their educational goals.

- Classcraft’s mission is to make school more relevant and meaningful by creating playful and collaborative learning experiences that teach the whole child. (https://www.classcraft.com, n.d.)

Education-focused social media platforms are controlled environments (as opposed to Facebook, Twitter etc.) specifically dedicated to learning purposes. The list of popular free educational social networks as provided by (http://ftp.edtechreview.in/trends-insights/trends/2606-educational-social-networks, n.d.) includes, most notably, Ted-Ed, TweenTribune, Edmodo, Wikispaces Classroom and TeacherTube.

- Ted-Ed (https://ed.ted.com/, n.d.) allows a teacher to create interactive lessons around YouTube videos by adding multiple choice and open-ended questions, discussion prompts, and additional resources.
- Tween Tribune enables teachers to create lessons around existing content, but this time articles rather than video.
- Edmondo is a communication platform where educational topics, resources and documents are constantly shared and discussed both publicly and in private groups (classes).

E-learning content

Electronic portfolio is a collection of electronic evidence assembled and managed by a user, usually on the Web. E-portfolios are both demonstrations of the user's abilities and platforms for self-expression. (https://en.wikipedia.org/wiki/Electronic_portfolio, n.d.)

Dedicated **learning platforms**:

1. Moodle is a learning platform designed to provide educators, administrators and learners with a single robust, secure and integrated system to create personalized learning environments. (https://moodle.org/, n.d.) Moodle provides the most flexible tool-set to support both blended learning and 100% online courses. (https://docs.moodle.org/36/en/About_Moodle#All-in-one_learning_platform, n.d.)
2. Open edX is the massively scalable learning software platform behind edX which is the online learning destination founded by Harvard and MIT in 2012. The mission stated by edX is to: “increase access to high-quality education, enhance teaching and learning on campus and online, and advance teaching and learning through research.” (https://open.edx.org/about-open-edx/, n.d.) The key parts of the platform are: 1) Learning Management System (LMS) and 2) course authoring Studio.

Prominent E-course providers:

3. Coursera (https://www.coursera.org/], n.d.) offers courses in the form of “interactive textbook, featuring pre-recorded videos, quizzes, and projects.” It supports learning community with discussion groups, and offers certification thorough worldwide partner Universities.
4. Udacity (https://www.udacity.com/, n.d.) “Virtually anyone on the planet with an internet connection and a commitment to self-empowerment through learning can come to Udacity, master a suite of job-ready skills, and pursue rewarding employment.”

UNS: Applied tools

Following the previous discussion, e-tools are classified into 4 categories:

1. Course authoring

2. Lab (HW, SW)
3. Asynchronous ("offline") learning
4. Synchronous ("online") learning

Tools used for laboratory are usually course specific, and therefore they will not be elaborated here. Instead, we will focus on ongoing interaction between course authoring, online and offline learning.

A majority of UNS courses use PowerPoint slides in traditional classrooms. Since PowerPoint allows audio embedding, it can produce video showing visual interaction with slides and being explained by lecturer narrations. Missing lecturer video can be additionally superimposed using external editing tools. From that perspective video conferencing tools, such as Zoom, WebEx, Skype etc. offer more complete course authoring environment. Due to unfortunate circumstances, in the summer semester of 2020. a majority of lectures are actually held through such telepresence (video conferencing) tools. The recorded sessions in video conferencing environment form a decent base for offline (asynchronous) learning materials. A majority of video conferencing tools integrate desktop/app screen capturing with lecturer video and audio recording. Currently, video conferencing tools are not standardized on the level of the institution with the result that all available products are being used.

During the previous year we have closely investigated Open edX platform, however it is not certain that current Moodle platform will be changed: users are accustomed to it, and it meets current needs. Therefore, all internally generated e-learning content is offered through access restricted Moodle page: http://moodle.telekom.ftn.uns.ac.rs/. In the next period Moodle platform will be intensively used for student evaluation. The development of this functionality is an ongoing activity for a majority of courses.

Telepresence requires additional tools (devices or robots) in order to improve interaction. Unfortunately, this area is not being properly explored up to now. The same applies to extended interaction tools in traditional classroom, such as application of whiteboards.

	E-TOOLS & Resources / Course:	Course Authoring	Lab (SW, HW)	Asynchronous ("offline") learning			Synchronous ("online") learning				
				E-learning content		Collaborative learning		Telepresence			Traditional classroom
				Internal learning platform	External			E-tutoring	Virtual classroom	Extended interaction	
1	M&SCS	PowerPoint	MATLAB, GNU Radio, USRP	Moodle	TBD	TBD		Zoom, WebEx		Pen tablet	~~whiteboard~~
2	CR	PowerPoint	MATLAB, GNU Radio, USRP	Moodle	TBD	TBD		Zoom, WebEx		Pen tablet	~~whiteboard~~
3											
4											
5											
6											
7											
8											
9											
10											

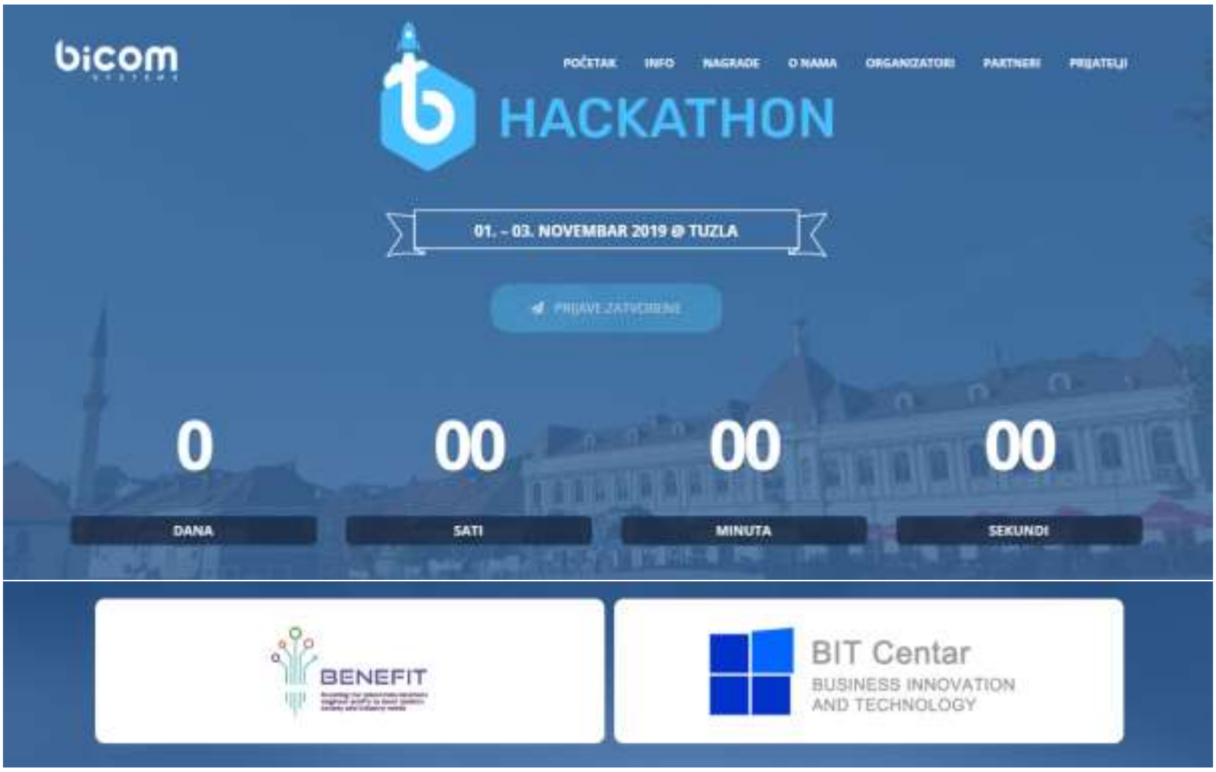
NOTES: Internal lerning platform includes Learning Management System (LMS)
To Be Determined - TBD

5. Development of Learning/teaching Methods Based on Student Competitions, Student Challenges and Hackathons

Particular attention within the BENEFIT project is given to the teaching and learning methodologies that are not only project-based, but stimulate an additional engagement of students during the realization of a project task. Such stimuli are found in scenarios where students, either individually or in a team, compete against each other. In recent years, the concept where student teams solve various problems competing against each other for a certain prize or some other recognition has become widespread and very popular under the name of student hackathon. Such events have developed more or less independently from the classical educational system, usually stimulated by a rising community of startup companies and small-to-medium ent erprises (SMEs) that have a particular interest in engaging the students in such a way. Hackathons quickly gained popularity among mostly Science-Technology-Engineering-Mathematics (STEM) student population and this could not have passed unnoticed by the academic teaching staff. Due to a great interest of students, it has become clear that including such concepts in traditional education is a necessity.

The first steps in including the concepts of student competitions and hackathons in the mainstream academic education were usually done by involvement of some of the academic staff members as the team leaders into such an event. At the University of Novi Sad, for example, we had a very successful example of such an engagement where several young assistant professors involved in the BENEFIT project prepared two teams for the prestigious Signal Processing Cup as part of the flagship IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) 2016 in Shanghai, China. Both teams were successful and were among the top ten teams to earn a honorary mention at the conference webpage (https://www2.securecms.com/ICASSP2016/SPCup.asp). The experience, excitement and knowledge gained at this competition, both for the students as well as for the staff members, were a clear indicator that such a learning methodology has clear benefits and may dramatically boost student enthusiasm for solving real-world problems. Such an approach has been discussed during several BENEFIT project teacher training events and currently, the entire BENEFIT consortium is well aware of this methodology and is ready to apply it in practice. One of the chances to do so has been this years Signal Processing Cup that took place at the IEEE ICASSP 2020 conference held virtually due to COVID-19 pandemic, in which the team from the University of Novi Sad has participated.

In order to demonstrate and train university teachers to use student competitions and hackathons more frequently in their teaching practice as a method to motivate students for outstanding dedication and progress, BENEFIT project has prepared a strategy based on organizing two hackathons and a training event on teaching and learning methodologies based on student competitions/hackathons. The first such event was kindly organized by one of the project industrial partners, BICOM company from Tuzla, Bosnia and Herzegovina, in November 2019 (https://hackathon.bicomsystems.com/). The goal of this event was to introduce other project partners to the practice of organizing such events, share best practices, but also, to engage students primarily from University of Tuzla, to engage in such events. The task of the hackathon was to design and create a mobile app that would exploit computer vision technologies or image processing techniques in order to solve relevantly identified real-world problem. Students were allowed to form teams of up to 5 persons and they had exactly 1 day (24 hours) to work on the task. During the competition, student teams received a support from a senior team mentor, an employee of Bicom Systems (project partner). The results of the student team work were then presented as part of 5-minute pitching presentation, followed up by questions from the jury. The jury evaluated the innovation, implementation and presentation quality of all teams.



The next two planned events are intended to train BENEFIT staff members with some of the world's best examples of competition based teaching as well as implementation of student hackathon collocated with such training event. For this purpose, it has been agreed within BENEFIT consortium that such an event should be held as part of BENEFIT Open Days project event, scheduled for June 2nd in Novi Sad, Serbia. However, deu to COVID-19 pandemic, the Open Event is postponed and will be held in December 2020 or January 2021, most likely in virtual online format. During the BENEFIT Open Day event, the teacher training will be held on using student competitions and hackathons as part of the regular academic course curricula. As a keynote speaker we selected Ivan Seskar, associate director of WINLAB, Rutgers University, as the main scientist in charge of one of the largest US wireless testbeds, called Open-Access Research Testbed for Next Generation Wireless Networks (ORBIT: https://www.orbit-lab.org/). Ivan Seskar possesses wide experience in training students for hands-on deployment of wireless communication systems and is ready to share his knowledge and views on student competition/hackathon-based teaching methodologies. We plan to use BENEFIT Open Day to organize additional student hackathon organized with the support of BENEFIT project, that would gather student teams from BENEFIT partners, but also other academic institutions from the Balkans and beyond.

Upon participating in BENEFIT endorsed and co-organized hackathons, and after the training event at BENEFIT Open Days event in Novi Sad, the teaching staff from BENEFIT academic partners in WBC will be aware and gain first-hand experience in how using learning and teaching methodologies based on student competitions and hackathons may improve their teaching practice. Among the main topics to be discussed, the methods of integration of such a teaching and learning practice into the traditional classroom will be investigated. There are, of course, many practical questions on how this should be done. The main avenue for using teaching methodology based on student competitions and hackathons is to use it in combination with problem-based learning, where students would solve specific problems during their course work, but would simultaneously participate in well-defined competitions. The questions of marking students in such cases, providing pass or fail decisions, deciding individual marks for students that participate in teams, are all very relevant and subject to discussion. In relation with the BENEFIT project, integration of such a teaching methodology and the collaboration with industrial partners could also offer interesting opportunities: for example, industrial partners could actively participate in defining competition/hackathon problems, but also, in providing additional incentives or awards for outstanding student performances. Certainly, BENEFIT events will greatly help teaching staff in understanding and implementing possibilities opened by teaching and learning methods based on competitions and hackathons in order to increase student satisfaction, excitement and dedication while acquiring specific knowledge and skills.

6. Innovative Training Methods Involving Industry – a Case Study of the Block-based Course

The industry partners involved in the BENEFIT project have analysed the previous experiences and, in collaboration with the academic partners, have proposed several ways to improve methods for teaching and training. The innovative methods have considered the need for students to acquire required skills in order to be competitive in the business market, while acquiring all the required knowledge that an academic level of studies requires.

One of the proposed methods is the block-based course, which is suggested for the practically oriented courses in the upper years of undergraduate academic studies and graduate academic studies. In this method, the students focus on one course at the time in the form of a block schedule. With the focus on one subject, the students can organize their time better and be motivated to finish the course within its block. The semester typically consists of 4-5 blocks.

In one example of the block-based semester, which has been applied at the Sub-department for Computer Engineering and Computer Communications at the Faculty of Technical Sciences, University of Novi Sad, the students of the 4th year of undergraduate studies take 5 courses in the winter semester and 3 courses in the summer semester. Each block is typically 3-4 weeks long, depending on the accredited number of classes for lectures and exercises.

A typical block starts with the lectures and practical classes in the first week. In the morning, lectures are held in the amount of 3-4 hours, depending on the course. After the lunch break, students are separated into groups and the laboratory computer exercises are organized for another 3-4 hours. The entire workload of a student in a typical day does not exceed the normal worktime of 8 hours, including the lunch break.

After the first week, some courses immediately follow with a project, while others opt to have 2 weeks of lectures. The courses which continue with lectures, typically have smaller projects or grading based on laboratory exercises and exam only. Majority of the courses opt for longer projects, as the project-based learning is very important for the final years of applied studies such as engineering.

Work on a project resembles the work students will have when they become employed in a company or institute. The project specification is given to the students and they have all the laboratory resources at their disposal to work on a solution to the project assignment. Students typically spend the entire workday at the laboratory, although some opt to work on their projects at home. Professors and teaching assistants are available for consultation during the working day, at the specified office hour sessions. Typically, at least one teaching assistant is available in the laboratory all the time.

During the project week(s), students do not only work on their project. They research how to solve it, read the assigned readings and study for the theoretical part of the exam. The theoretical exam is typically organized in one of the two slots: Monday of the final project week (so that the students have time stress-free from the exam to finish the project), or the Monday following the final project week (so that the students have the weekend for preparation for the exam, whereafter they present their project results). It is up to the teacher to choose which slot is better for their course.

If a student does not pass the exam during its block, there are two possible scenarios. If the student acquired enough practical points, i.e. points in the attendance, activities in the class, laboratory exercises and the project, he/she can re-take the theoretical exam multiple times in the regular exam periods defined by the University. If the student has not acquired enough practical points, he/she must take the entire course again next year. Typically, a large majority (>90%) of students acquire enough practical points during the block since a particular course is their only focus during the block.

There are several advantages of this approach: a focus on a single course allows a student to better understand the material and focus on passing one course at a time. Experience has shown that the rate of students that pass the course in time is much larger than the rate in classical courses. In addition, project-based learning reaches its peak in this approach, since the project the student is working on is not interfered by other courses or project and with the full focus, the student can grasp most of the practical knowledge from the project.

One disadvantage of this approach is the fact that the condensed block of a single course means that the knowledge does not have time to be absorbed into long-term memory in the same way as it is absorbed in the classical semester-long course. Therefore, the block-based approach is good for practical courses near the end of the studies, but it is not recommended for more theoretical courses typically taken in the first few years of undergraduate studies.

7. Two-subject project-based learning: Pilot projects

At the School of Electrical Engineering, the University of Belgrade, two pilot projects related to multi-subject project-based learning approach were realized during the school years 2018-2019 and 2019-2020. Both projects were realised for the students of the Study module Telecommunications and Information Technology.

Two-subject project in 6th semester

The first project was realized for the students of their third year of study (out of four), 6th semester, during the spring semester in 2019. The project assignment was related to two subjects, Telecommunications 3 (mandatory subject, lecturers Goran Marković, Kristina Josifović) and Signal Processing 2 (elective subject, lecturers Jelena Ćertić, Miloš Bjelić). The two different project assignments were offered as a two-subject project:

1. The project built on the 5G solution proposed in the conference paper (X. Zhang, M. Jia, L. Chen, J. Ma, and J. Qiu, "Filtered-OFDM - Enabler for Flexible Waveform in the 5th Generation Cellular Networks," 2015 IEEE Global Communications Conference (GLOBECOM), San Diego, CA, 2015, pp. 1-6.)
2. The project related to simulation of the GSM system with three-step decimation in the receiver.

The theoretical aspects of GSM and OFDM technology are topics of the subject Telecommunications 3. Advances in filter design and implementation, including decimation are topics of the subject Signal Processing 2. Semestral project is the obligatory part of the subject Signal processing 2, however, not all projects are directly related to themes covered by subject Telecommunications 3 (there are themes related to audio signal processing, and classical DSP topics such as filter design and implementation, adaptive algorithms, spectral estimation, etc.). For that reason, the multi-subject project was offered as an option for the students. The project assignment is usually done in small groups of students (up to four students). There were five groups of students that took the multi-subject project, four groups selected the theme related to 5G and one group selected the theme related to GSM. At the end of the semester, the project assignments were defended before the subjects' teachers and all students of the subject Signal processing 2. Students asked questions and graded the defended projects. The four projects were finished and defended in time, and the overall scores for the presentations are given in Table 3 (grade range 1 to 5).

Table 3. *The overall score of the teams obtained by other students*

Team	**The goal of the project is clearly stated**	**Presentation of the main idea of the solution**	**Developed solution**	**Presentation of the results**	**Overall impression**
Group 1	**4.57**	**4.79**	**4.73**	**4.71**	**4.86**
Group 2	**4.73**	**4.36**	**4.45**	**4.55**	**4.55**
Group 3	**5.00**	**4.62**	**4.60**	**4.70**	**4.87**
Group 4	**4.80**	**4.87**	**4.27**	**4.30**	**4.60**

Lessons learned

The students enjoyed the challenge of performing the task that is related to real-life topics. We asked them a set of typical exam questions, but the answers shown a deeper understanding of the topic comparing to an average group. Students certainly got a better understanding of the advantages and drawbacks of OFDM technology, and better insight into the implementation issues of the filters in telecommunications transmitters and receivers. It was interesting that all four groups of students organised their defences in a specific way, i.e. there were no similarities between their performances. The students were very active during the defences, they asked questions, and they were free to give their opinions and comments. Based on the good results, we decided to offer similar projects in the future.

Two-subject project in 5th semester

The second project was realized for the students of their third year of study (out of four), 5th semester, during the autumn semester in 2019. The project assignment was related to two mandatory subjects, Telecommunications 2 (lecturers Goran Marković, Kristina Josifović) and Signal Processing 1 (lecturers Jelena Ćertić, Miloš Bjelić). Although the subjects are mandatory, the project itself is elective. For subject Signal processing 1 it could be taken as a replacement for the (obligatory) practical work related to the implementation of digital signal processing algorithms in MATLAB/Octave. For subject Telecommunications 2, the project score can improve the overall grade. The topic of the project was the simulation of the telecommunication system based on QPSK modulation. The simulation model was fully explained and partly developed by the teachers. The project was chosen by about 20% of the students. The students also had the option to implement their solution by using software-defined radio (SDR) platform (ADALM Pluto – donated by Analog Devices), and two project groups opted for that.

Lessons learned

Students stated that the project helped them to better understand the entire hierarchy of the telecommunications system and the role of the basic signal processing in the telecommunications system. Further, students improve their perspective of the Telecommunications and Information technology module as a complete module, not just a bunch of different subjects. We are planning to offer this type of project regularly, for now as an optional task.

8. Conclusions

The deliverable D3.1 “Development of modernized teaching methodologies”, related to the adoption of novel learning/teaching methods, has presented a wide array of different innovative teaching methodologies that can be used to modernize existing university curricula in the area of telecommunications engineering. After the analysis of advantages and disadvantages of the presented methods, the consortium members, drawing from their own recent experience with innovation in higher education in the domain of telecommunications engineering, have selected a reduced number of methods that will be implemented in a number of courses within the modernized telecommunications study programmes at their universities. In some cases project partners will begin introducing novel practices into existing courses, while in other cases new courses will be organized, either completely based on selected innovative methods, or constituting a selected innovative method as one of their principal components (this is, to some extent, determined by the accreditation cycles that vary from one project partner to another).

The selected methods most notably include:

- The introduction of **student competitions** or hackathons as an important supplement to the regular curricular activities, and more generally, introduction of a competitive element in student interaction as well as evaluation of their results – this is expected to boost the students’ confidence that they will be able to overcome similar challenges in the future, it will contribute to the acquisition of skills that are not regularly acquired through standard teaching methods, and it will help students appreciate the advantages of participation in teamwork. This method also opens interesting perspectives for cooperation with the industry, which could play an important role in defining the challenges, evaluating the results, and establishing connections with their future employees, giving them a clearer picture of what will be expected from them when they join the competitive labour market. As concrete steps towards this goal, several competition teams have been set up including a number of highly motivated students, with the aim of participation at forthcoming scientific and technological challenges such as the IEEE Signal Processing Cup.

- The introduction of general **project-based learning methods**, preferably with evaluation of results through student presentations, which will improve a range of student skills, including the capacity to recognize that a certain model from a fundamental science fits a specific real-life situation, the ability to apply known algorithms to successfully solve a given problem or to conduct research necessary to modify these algorithms or discover new ones with the same aim, the ability to present their results orally and overcome the anxiety related to public presentation, the ability to defend their stance with proper argumentation and thus develop their general communication skills, particularly in the domain of their future expertise.

- The introduction of **block-courses** (OCAT – one course at a time), which is a method tightly related with project-based learning, and particularly useful at later years of study, when it is most important that the students should establish clear connections between fundamental knowledge, acquired during earlier years, as well as practical situations where this fundamental knowledge is expected to come in useful; this method is also particularly convenient for engineering courses since it enables efficient combination of lectures and laboratory sessions (e.g. in the mornings and in the afternoons). Another advantage of this approach is that it prevents students from being distracted from other topics while the course is in progress.

- The introduction of **distance learning**, as a method that can be used as an auxilliary tool for either the delivery of courses or for evaluation of student results; this approach includes a range of different methods, which establish interaction between the teacher and the learner to a greater or lesser extent, using different communication modalities. An unforeseen factor in the introduction of this method is that, due to the ongoing worldwide health crisis, by mid-2020 virtually all of the teaching/learning processes in the countries of project participants (as well as worldwide) are expected to be carried out remotely. This factor has accelerated the introduction of distance learning, which is resulting in the creation of a large repository of learning material (such as video-presentations), that will be usable in the future as well.

The introduction of all these methods into the curricula of higher education institutions that participate in the BENEFIT project will be greatly facilitated by the existence of 6 laboratories created within the project, jointly by participating universities and their partners from industry:

- University of Banja Luka: “Signal Processing in Telecommunications Lab“ in collaboration with Bicom and AlfaNum;
- University of Sarajevo: “Telecommunications Lab” in collaboration with BIT Centre;
- University of Tuzla: “VoIP Services Lab“ in collaboration with Bicom and BIT Centre;
- 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.

described in more detail in the deliverable D3.2 “Creation of 6 joint University-Industry Labs”.

The deliverable D3.1, “Development of modernized teaching methodologies” represents the response of the project partners to the need for a new type of syllabus that should, on one side, cover the main topics, but, on the other side, also provide sufficient resources and intellectual stimuli for the students to grasp the current state of the art in the field of telecommunications, and give them the motivation for hard work that is necessary for acquiring the expertise in the field and competitiveness on the labor market. Furthermore, with increasing importance of intellectual property and innovation, it is the task of higher education to create future employees with good ideas, with skills that are not usually acquired during standard university education, and most importantly, the ability to efficiently use the acquired knowledge to successfully address any given problem.

9. References

Bekkers, R., & Bombaerts, G. (2017). Introducing Broad Skills in Higher Engineering Education: The Patents and Standards Courses at Eindhoven University of Technology. *Technology & Innovation, 19*, 493-507.

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *The Clearing House, 83*, 39-43.

Brown Wright, G. (2011). Student-centered learning in higher education. *International Journal of Teaching and Learning in Higher Education, 23*, 92-97.

Bruner, R. F. (2003). Socrates' muse: Reflections on effective case discussion leadership.

Burns, M. (2011). *Distance Education for Teacher Training: Modes, Models and Methods.* Retrieved from http://idd.edc.org/sites/idd.edc.org/files/Distance%20Education%20for%20Teacher%20Training%20by%20Mary%20Burns%20EDC.pdf

Delić, V., Mišković, D., Suzić, S., Delić, T., Popović, Jakovljević, N., & Sečujski, M. (2019, 2). Central Audio Library of the University of Novi Sad (in Serbian). *XXV Skup Trendovi razvoja: "Kvalitet visokog obrazovanja".* Kopaonik: Faculty of Technical Sciences.

E-learning methodologies - A guide for designing and developing e-learning courses. (2011). Retrieved from http://www.fao.org/3/i2516e/i2516e.pdf

Fry, H., Ketteridge, S., & Marshall, S. (2008). *A handbook for teaching and learning in higher education: Enhancing academic practice.* Routledge.

Galusha, J. M. (n.d.). *Barriers to Learning in Distance Education*. Retrieved from https://web.archive.org/web/20000229041104/http://www.infrastruction.com/barriers.htm

Garrote Jurado, R. &.-G. (2014). Classification of the Features in Learning Management Systems. *XVII Scientific Convention on Engineering and Architecture.* Havana, Cuba.

Guthrie, R., & Carlin, A. (2004). Waking the dead: Using interactive technology to engage passive listeners in the classroom. *AMCIS 2004 Proceedings*, 358.

http://3dgamelab.com/. (n.d.). Retrieved 2019

http://blogs.worldbank.org/edutech/. (n.d.). Retrieved 2019

http://blogs.worldbank.org/edutech/iri. (n.d.). Retrieved 2019

http://ftp.edtechreview.in/trends-insights/trends/2606-educational-social-networks. (n.d.). Retrieved 2019

https://docs.moodle.org/36/en/About_Moodle#All-in-one_learning_platform. (n.d.). Retrieved 2019

https://ed.ted.com/. (n.d.). Retrieved 2019

https://en.wikipedia.org/wiki/Blended_learning. (n.d.). Retrieved 2019

https://en.wikipedia.org/wiki/Blog. (n.d.). Retrieved 2019

https://en.wikipedia.org/wiki/Distance_education. (n.d.). Retrieved 2019

https://en.wikipedia.org/wiki/Educational_technology. (n.d.). Retrieved 2019

https://en.wikipedia.org/wiki/Electronic_portfolio. (n.d.). Retrieved 2019

https://en.wikipedia.org/wiki/M-learning. (n.d.). Retrieved 2019

https://en.wikipedia.org/wiki/Screencast. (n.d.). Retrieved 2019

https://moodle.org/. (n.d.). Retrieved 2019

https://open.edx.org/about-open-edx/. (n.d.). Retrieved 2019

https://secondlife.com/. (n.d.). Retrieved 2019

https://teach.com/what/teachers-know/teaching-methods/?_ga=2.73346323.106813785.1551566905-2102080725.1551566905. (2019).

https://telepresencerobots.com/robots/kubi. (n.d.). Retrieved 2019

https://www.classcraft.com. (n.d.). Retrieved 2019

https://www.coursera.org/]. (n.d.). Retrieved 2019

https://www.doublerobotics.com/. (n.d.). Retrieved 2019

https://www.revolverobotics.com. (n.d.). Retrieved 2019

https://www.rezzly.com/. (n.d.). Retrieved 2019 *https://www.udacity.com/*. (n.d.). Retrieved 2019

Jayashree, R. (2017, 11). A Study on Innovative Teaching Learning Methods for Undergraduate Students. *International Journal of Humanities and Social Science Invention, 6*, 32-34.

Jordan, K. (2014). Initial trends in enrolment and completion of massive open online courses. *The International Review of Research in Open and Distributed Learning, 15*.

Kapp, K. (2012). *The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education.* Pfeiffer.

Lever-Duffy, J., & McDonald, J. B. (March 2007). *Teaching and Learning with Technology.* Addison-Wesley.

Lillejord, S., Børte, K., Nesje, K., & Ruud, E. (2018). *Learning and teaching with technology in higher education -- a systematic review.* Tech. rep., Oslo: Knowledge Center for Education.

Magoha, P. W. (2002). Effective methods and tools for training engineers and technologists: regional trends. *World Transactions on Engineering and Technology Education, 1*, 209-215.

Mommers, J., Schellings, G. L., & Beijaard, D. (2015). Growing as a teacher: workshops for stimulating professional identity development in education.

Moran, M., Seaman, J., & Tinti-Kane, H. (2011). Teaching, Learning, and Sharing: How Today's Higher Education Faculty Use Social Media. *Babson Survey Research Group*.

Mumtaz, S., & Latif, R. (2017). Learning through debate during problem-based learning: an active learning strategy. *Advances in physiology education, 41*, 390-394.

Osborn, A. F. (1953). *Applied imagination: Principles and Procedures of Creative Problem Solving.* New York: Charles Scribner's Sons.

Östlund, B. (n.d.). *Stress, disruption and community — Adult learners' experiences of obstacles and opportunities in distance education*. Retrieved from http://www.eurodl.org/index.php?p=&sp=full&article=179

Patil, S. A., & Prasad, S. R. (2016). Innovative Methods of Teaching & Learing Electronics Engineering. *Journal of Engineering Education Transformations*.

Seery, M. K. (2010). Using pre-lecture resources in your teaching: A short guide. *Journal of Chemical and Pharmaceutical Sciences, 3*, 1-3.

Taneja, M. P., Safapour, M. E., & Kermanshachi, S. (2018, 6). Innovative Higher Education Teaching and Learning Techniques: Implementation Trends and Assessment Approaches. *ASEE Conference & Exposition*, (p. 23998).

Trujillo-Aguilera, D., Sotorrio Ruiz, P. J., Pozo Ruz, A., Vegas, M.n., & Javier, F. (2015). A new challenge in the Electronics teaching/learning process for the Industrial Design Engineering Bachelor. An interactive educational tutorial. *EDUCON - Global Engineering Education Conference.* Retrieved from https://riuma.uma.es/xmlui/handle/10630/9312

Tucker, B. (2012). The flipped classroom: Online instruction at home frees class time for learning. *Education next, 12*, 82-84.

Watteyne, T., Tuset-Peiro, P., Vilajosana, X., Pollin, S., & Krishnamachari, B. (2017). Teaching communication technologies and standards for the industrial IoT? Use 6TiSCH! *IEEE Communications Magazine, 55*, 132-137.

World Bank Group. (February 2015). *Expanding Access to Early Childhood Development USING INTERACTIVE AUDIO INSTRUCTION.* Retrieved from https://www.earlychildhoodworkforce.org/download/file/fid/127

Zaidieh, A. J. (2012). The use of social networking in education: Challenges and opportunities. *World of Computer Science and Information Technology Journal (WCSIT), 2*, 18-21.

Schaller, C.G. and Hadgraft, R. (2013) ‘‘Developing student teamwork and communication skills using multi-course project-based learning using multicourse project-based learning,’’ in Proc. AAEE Conf., Dec. 2013, pp. 1–10