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Version	Date	Author(s)	Organization(s)	Brief description of change
1	01.04.2022	Jorge M. Finochietto	UNC	Initial draft

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1. Introduction

The main objective of the NEON project is to improve and diversify the training of human resources, both in the academic field and in the public-private sphere, motivating innovative technologies in the Information and Communications Technologies (ICT) field, in particular the Internet of Things (IoT). The main goal of the institutions that make up the consortium is the creation of a Network of Competence (NoC) for IoT. The project will offer the framework and support to foster the industry collaboration at each country of interest, namely, Argentina and Uruguay, and, at the same time, it offers the possibility of exchange and advice from two European countries: Austria and Spain, that have demonstrated a good amount of development and innovation in the IoT field. The project's goals will be achieved by updating and improving the curricula at the different university degrees, the creation of at least 5 laboratories on IoT, the training of their academic staff and the collaboration between the local and regional industry.

Latin America (LA) is a region of the world that still does not offer a sufficient level of equal opportunities. One of the reasons for this disparity can be identified in a constantly growing population and an increasing urbanization into big and densely populated metropolises. The southern regions, especially Argentina and Uruguay, operate mostly in the primary sector of agricultural goods, mainly food. Most advanced economy sectors including high-tech industry are not well developed. Furthermore, unemployment is a constant and worrying issue in LA. Argentina and Uruguay are among the top riders of LA with the highest unemployment rates as a result of a great deterioration of economy and a general decrease of the average Gross Domestic Product (GDP) due to scarce diversity in industry, lack of innovation, lack of qualified personnel especially in technology. Engineers are scarce in all areas, especially ICT. The demand is higher than the offer. Among the high tech market sectors, Internet of Things is extremely relevant since it spans several application domains, from quality and environmentally friendly agriculture, to cattle rising, to smart energy and renewables, to health applications, to the holistic vision of smart cities.

The European Union (EU) character of the project will ensure modernization of the engineering profile with the inclusion of IoT skills and knowledge by having EU Higher Education Institutions (HEI)s bring their experience and help to enhance the quality of the study programmes. Value will be attained by creating more skilled and competent graduates, which will reflect in better-qualified engineers that work in ICT companies, with specialization in IoT, and contribute to the innovation process of such companies at EU levels. Study programme improvements, innovative teaching and training methodologies, new labs, and internships will result in students being better prepared for a flexible international job market, recognized by employers at EU level, which enhances mobility opportunities. NEON focus is on IoT, which is aligned with the EU strategy of stimulating the wider application of ICT in society and economy. The objectives will be attained only if HEIs in LA and EU countries work together to exchange good practices, enhance curricula and their contents, and facilitate mutual studies and degrees recognition as well as cooperation with industry. LA companies will also benefit by rendering themselves more visible at EU level, potentially diminish the drain of experts and attract employees from the EU.

In this context, the adoption of modernized teaching methodologies can contribute to the training of human resources, both in the academic field (students, professors, technicians) and in the public - private sphere, in the field of the Internet of Things is a necessary step towards achieving the ultimate goal of the NEON project. In order to adopt these methodologies, it is important to identify them and evaluate how they can be implemented in IoT courses.

2. Objectives of the Deliverable

The aim of Work Package 3 (WP3) is to adopt novel learning/teaching methods and develop classes to modernize teaching on IoT subjects. From the HEI partners' perspective, there are considered discussion panels and mutual visits, that will provide Latin American teaching staff with 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. Considering industrial partners that aim to stimulate creativity, innovation and entrepreneurship, it will be followed by an unconventional teaching practice (lecturing and examination through project tasks, implementation / development challenges, hackathons, etc.). In order to identify those innovative teaching methodologies that can be used for the classes on IoT subjects, the following procedure was proposed, agreed among partners and realized:

- Understand the current adoption of innovative teaching methodologies among teachers who will develop the teaching material, and asses their determination to adopt them
- Identify a set of different innovative teaching methodologies that could be used for developing the teaching material, and provide a clear definition of each one
- Inquiry all teachers about the methodologies that they propose to implement in their teaching material, including the type of material that will be produced and the lab equipment that will be required.

3. Analysis of current adoption of innovative teaching methodologies

An initial survey was carried out for all teachers within the NEON project partners who are working in the creation and/or modernization of teaching material related to IoT courses to better understand their current teaching methodologies and identify those that could be adopted. This survey was based on a broader multinational study called Innovative Teaching and Learning (ITL) Research and several questions have been adapted from the School Transformation Survey (STS) proposed by Microsoft Education.

For this assessment we have collected 16 responses in Spanish and 1 in English. The whole process has served us to reflect about the three pillars proposed by the survey:

- Student-centered pedagogy includes practices of teaching and learning that are project-based, collaborative, foster knowledge-building, require self-regulation and assessment, and are both personalized (allowing for student choice and relevance to the individual student) as well as individualized (allowing students to work at their own pace and according to their particular learning needs);
- Extending learning beyond the classroom which refers to learning activities that reflect the nature of high performing work groups in modern organizations. Learning activities extend beyond the traditional boundaries of the classroom, for example, by including individuals beyond the classroom (for example, family, friends, experts, community members), by providing opportunities 24/7 learning (for example, research outside the classroom), fostering cross-subject connections, and promoting global awareness and cultural understanding;
- ICT used for teaching and learning which relates to technology use by educators and by students for learning purposes. Because the impact of information and communication technologies (ICT) can vary widely depending on its pedagogical application, this construct includes a focus on how ICT is used and not simply whether it is used.

The survey was created using Google forms, and it has served to understand the current methodologies used by teachers and the way they teach students nowadays. It included questions of multiple choice grid such as: Have you ever proposed students to use ICT to find information on the Internet? Or, Have you ever asked students to work with peers from outside their classroom for extending the classroom to the community?; Have you ever allowed students to choose their own topics of learning or questions to address student needs or interests (i.e., personalized learning)? A total of 47 questions organized in the 3 above mentioned pillars were asked about whether the teacher has ever adopted some specific teaching practice, with the following possible answers:

- Yes, with results as expected or beyond.
- Yes, but the results were not as expected.
- Never but could soon.
- Never but could eventually.
- Never and not plan.

The main findings of this survey were the following:

- About 53.3% of the answers were “Yes, with results as expected or beyond.”, which demonstrated that a good adoption of innovative teaching methodologies
- About 26.8% of the answers were “Never but could soon.”, which also showed both the interest and willingness to adopt new methodologies in the short term, in particular, for IoT courses under development
- About 12.6% of the answers were “Never but could eventually.”, which highlighted the value of some methodologies that could be adopted in the future, but not necessarily on the planned IoT courses.
- Only 6.5% of the answers were “Yes, but results were not as expected.”, which may reveal that some methodologies are hard to implement or not suited for some courses.
- Less than 1% of the answers were “Never and not plan.”, which confirms that the methodologies are in general of interest and applicable for teaching IoT courses.

4. Identification of innovative teaching methodologies for IoT courses

Based on the answers from the survey 6 innovative teaching methodologies were identified, defined and proposed to teachers involved in the development of the course material. These methodologies were the following:

- **Flipped classroom**[1]: “A flipped classroom is an instructional strategy and a type of blended learning, which aims to increase student engagement and learning by having pupils complete readings at home and work on live problem-solving during class time. This pedagogical style moves activities, including those that may have traditionally been considered homework, into the classroom. With a flipped classroom, students watch online lectures, collaborate in online discussions, or carry out research at home, while actively engaging concepts in the classroom, with a mentor's guidance. In traditional classroom instruction, the teacher is typically the leader of a lesson, the focus of attention, and the primary disseminator of information during the class period. The teacher responds to questions while students defer directly to the teacher for guidance and feedback. Many traditional instructional models rely on lecture-style presentations of individual lessons, limiting student engagement to activities in which they work independently or in small groups on application tasks, devised by the teacher. The teacher typically takes a central role in class discussions, controlling the conversation's flow.

[1] https://en.wikipedia.org/wiki/Flipped_classroom

Typically, this style of teaching also involves giving students the at-home tasks of reading from textbooks or practicing concepts by working, for example, on problem sets."

- **Project-based learning**[2]: "Project-based learning (PBL) is a student-centered pedagogy that involves a dynamic classroom approach in which it is believed that students acquire a deeper knowledge through active exploration of real-world challenges and problems. Students learn about a subject by working for an extended period of time to investigate and respond to a complex question, challenge, or problem. It is a style of active learning and inquiry-based learning. PBL contrasts with paper-based, rote memorization, or teacher-led instruction that presents established facts or portrays a smooth path to knowledge by instead posing questions, problems or scenarios."
- **Problem-based learning**[3]: "Problem-based learning (PBL) is a student-centered pedagogy in which students learn about a subject through the experience of solving an open-ended problem found in trigger material. The PBL process does not focus on problem solving with a defined solution, but it allows for the development of other desirable skills and attributes. This includes knowledge acquisition, enhanced group collaboration and communication. The PBL process was developed for medical education and has since been broadened in applications for other programs of learning. The process allows for learners to develop skills used for their future practice. It enhances critical appraisal, literature retrieval and encourages ongoing learning within a team environment. The PBL tutorial process often involves working in small groups of learners. Each student takes on a role within the group that may be formal or informal and the role often alternates. It is focused on the student's reflection and reasoning to construct their own learning. The Maastricht seven-jump process involves clarifying terms, defining problem(s), brainstorming, structuring and hypothesis, learning objectives, independent study and synthesis. In short, it is identifying what they already know, what they need to know, and how and where to access new information that may lead to the resolution of the problem. The role of the tutor is to facilitate learning by supporting, guiding, and monitoring the learning process. The tutor aims to build students' confidence when addressing problems, while also expanding their understanding. This process is based on constructivism. PBL represents a paradigm shift from traditional teaching and learning philosophy, which is more often lecture-based. The constructs for teaching PBL are very different from traditional classroom or lecture teaching and often require more preparation time and resources to support small group learning."
- **Collaborative learning**[4]: "Collaborative learning is a situation in which two or more people learn or attempt to learn something together. Unlike individual learning, people engaged in collaborative learning capitalize on one another's resources and skills (asking one another for information, evaluating one another's ideas, monitoring one another's work, etc.). More specifically, collaborative learning is based on the model that knowledge can be created within a population where members actively interact by sharing experiences and take on asymmetric roles. Put differently, collaborative learning refers to methodologies and environments in which learners engage in a common task where each individual depends on and is accountable to each other. These include both face-to-face conversations and computer discussions (online forums, chat rooms, etc.). Methods for examining collaborative learning processes include conversation analysis and statistical discourse analysis. Thus, collaborative learning is commonly illustrated when groups of students work together to search for understanding, meaning, or solutions or to create an artifact or product of their learning. Furthermore, collaborative learning redefines the traditional student-teacher relationship in the classroom which results in controversy over whether this paradigm is more beneficial than harmful. Collaborative learning activities can include collaborative writing, group projects, joint

[2] https://en.wikipedia.org/wiki/Project-based_learning
[3] https://en.wikipedia.org/wiki/Problem-based_learning
[4] https://en.wikipedia.org/wiki/Collaborative_learning

problem solving, debates, study teams, and other activities. The approach is closely related to cooperative learning."

- **Case study**[5]: "A case study is an in-depth, detailed examination of a particular case (or cases) within a real-world context For example, case studies in medicine may focus on an individual patient or ailment; case studies in business might cover a particular firm's strategy or a broader market; similarly, case studies in politics can range from a narrow happening over time (e.g., a specific political campaign) to an enormous undertaking (e.g., a world war). Generally, a case study can highlight nearly any individual, group, organization, event, belief system, or action. A case study does not necessarily have to be one observation (N=1), but may include many observations (one or multiple individuals and entities across multiple time periods, all within the same case study). Research projects involving numerous cases are frequently called cross-case research, whereas a study of a single case is called within-case research. Case study research has been extensively practiced in both the social and natural sciences."
- **Experiential learning**[6]: "Experiential learning (ExL) is the process of learning through experience, and is more narrowly defined as "learning through reflection on doing". Hands-on learning can be a form of experiential learning, but does not necessarily involve students reflecting on their product. Experiential learning is distinct from rote or didactic learning, in which the learner plays a comparatively passive role. It is related to, but not synonymous with, other forms of active learning such as action learning, adventure learning, free-choice learning, cooperative learning, service-learning, and situated learning. Experiential learning is often used synonymously with the term "experiential education", but while experiential education is a broader philosophy of education, experiential learning considers the individual learning process. As such, compared to experiential education, experiential learning is concerned with more concrete issues related to the learner and the learning context. Experiential learning entails a hands-on approach to learning that moves away from just the teacher at the front of the room imparting and transferring their knowledge to students. It makes learning an experience that moves beyond the classroom and strives to bring a more involved way of learning."

5. Selection of teaching methodologies for proposed IoT courses

A total of 21 projects to develop teaching material were proposed by the latinamerican partners: UdelaR (5), UCU (1), UNMDP (3), UNS (7) and UNC (5). For each project one or more innovative teaching methodologies were selected as follows:

- Flipped classroom (2 projects)
- Project-based learning (15 projects)
- Problem-based learning (9 projects)
- Collaborative learning (14 projects)
- Case study (11 projects)
- Experiential learning (18 projects)

Besides for the development of the material different type of activities and resources were proposed as follows:

- Slide lessons (18 projects)
- Video lecturing (8 projects)
- Worksheets (5 projects)

[5] https://en.wikipedia.org/wiki/Case_study
[6] https://en.wikipedia.org/wiki/Experiential_learning

- Auto-Quiz (4 projects)
- Hands on activities (16 projects)

More details on each projects are illustrated in Figure 1, where each column of the table indicates the following:

- Project name
- Number of authors that will contribute to the material
- The categories to which the material can be associated:
    - IoT System Integration
    - IoT Connectivity and Networks
    - IoT Data Analytics
    - IoT Applications
    - Hardware for IoT systems;
- The expected outcomes of the project. The available options are:
    - New entire course (the material covers entirely a new course, which has never been delivered)
    - Full update of existing course (the material covers entirely a new course, this material will update existing one and/or new one)
    - Partial update of existing course (the material only covers a part of an existing course, this material will update existing one or/and add new one)
- The teaching contents that will be developed. Available options are:
    - Slide lessons
    - Video lecturing
    - Worksheets
    - Auto-Quiz
    - Hands on activities
- The teaching methodologies: modern teaching methodologies that are proposed in the associated material. A preliminary list of these methodologies are
    - Flipped classroom
    - Project-based learning
    - Problem-based learning
    - Collaborative learning
    - Case study
    - Experiential learning
- The required labs that are being installed in the partner to delivery the teaching material
- The delivery targets indicating the level of the associated education program level (U: undergraduate, G: graduate, C: continuing education)
- The license under which the material will be released, where all 21 projects agreed on the Attribution 4.0 International (CC BY 4.0) license

Project Name	# Authors	Category					Expected Outcome			Contents					Teaching Methodologies					
		IoT System Integration	IoT Connectivity and Networks	IoT Data Analytics	IoT Applications	Hardware for IoT	New entire course	Full update of existing course	Partial update of existing course	Slide lessons	Video lecturing	Worksheets	Auto-Quiz	Hands on activities	Flipped classroom	Project-based learning	Problem-based learning	Collaborative learning	Case study	Experimental learning
Hands on IoT	5	✓	✓		✓		✓			✓	✓		✓	✓		✓	✓		✓	✓
Software Defined Radio (SDR) based Communications Systems	4	✓	✓		✓	✓	✓			✓	✓		✓	✓		✓	✓	✓	✓	✓
Hardware and Microwave Circuit design for IoT	4	✓	✓			✓	✓			✓	✓	✓		✓		✓	✓	✓	✓	✓
IoT in Agribusiness	1		✓		✓		✓			✓				✓		✓		✓		✓
Antenna Design	1	✓	✓				✓			✓		✓		✓		✓	✓	✓	✓	✓
Real-time Embedded Systems	2	✓				✓			✓	✓				✓		✓		✓		✓
Wireless Sensor Networks	2		✓		✓	✓			✓	✓				✓		✓		✓		✓
Digital Design for Low Power	2					✓			✓	✓				✓		✓		✓		✓
Communication Technologies for IoT	1		✓		✓	✓		✓		✓						✓		✓		✓
Fundamentals of Internet of Things	2		✓		✓		✓			✓		✓	✓			✓				
Cognitive Radio	3		✓	✓				✓			✓			✓	✓				✓	✓
Data and connectivity management for IoT	1		✓		✓				✓	✓			✓	✓		✓		✓		✓
Communications Labs	3		✓						✓		✓			✓	✓				✓	✓
IoT Programming	1				✓				✓	✓				✓			✓			
Fundamentals of communication systems	3		✓						✓	✓							✓	✓		✓
Radiofrecuency circuits design	1		✓		✓				✓	✓	✓	✓		✓		✓		✓	✓	
Introduction to digital communications	3		✓						✓	✓							✓	✓		✓
Antennas	1		✓		✓		✓			✓				✓		✓			✓	✓
Radio-localization and radar	1				✓				✓		✓			✓			✓		✓	✓
Cellular IoT Systems	3		✓				✓			✓						✓		✓	✓	✓
Wireless Communications Systems	1				✓				✓	✓	✓	✓		✓		✓	✓	✓	✓	✓
TOTAL		5	16	1	12	6	8	2	11	18	8	5	4	16	2	15	9	14	11	18

Project Name	Required Labs						Delivery Targets			License		Partner				
	Communications Technology applied to IoT (UNdMP)	IoT Laboratory (UCU)	Iot Laboratory (UdelaR)	IoT Campus Living Lab (UNC)	SDR Lab (UNC)	Signal processing for Communications Laboratory (UNS)	U (Undergraduate)	G (Graduate)	C (Continuous Education)	CC-BY-4.0	Other	UNMDP	UCU	UdelaR	UNC	UNS
Hands on IoT	✓						✓	✓	✓	✓		✓				
Software Defined Radio (SDR) based Communications Systems	✓						✓	✓	✓	✓		✓				
Hardware and Microwave Circuit design for IoT	✓						✓	✓	✓	✓		✓				
IoT in Agribusiness		✓								✓			✓			
Antenna Design			✓					✓	✓	✓				✓		
Real-time Embedded Systems			✓				✓	✓	✓	✓				✓		
Wireless Sensor Networks			✓				✓	✓	✓	✓				✓		
Digital Design for Low Power			✓					✓	✓	✓				✓		
Communication Technologies for IoT			✓					✓	✓	✓				✓		
Fundamentals of Internet of Things				✓				✓		✓					✓	
Cognitive Radio					✓		✓	✓		✓					✓	
Data and connectivity management for IoT				✓			✓			✓					✓	
Communications Labs					✓		✓	✓		✓					✓	
IoT Programming				✓			✓			✓					✓	
Fundamentals of communication systems						✓	✓			✓						✓
Radiofrecuency circuits design						✓	✓			✓						✓
Introduction to digital communications						✓	✓			✓						✓
Antennas						✓	✓			✓						✓
Radio-localization and radar						✓	✓			✓						✓
Cellular IoT Systems						✓		✓	✓	✓						✓
Wireless Communications Systems						✓	✓			✓						✓
TOTAL	3	1	5	3	2	7	13	11	8	18	0	3	1	5	5	7

Figure 1 - Proposed teaching material projects and their characteristics

6. Conclusions

As described throughout this document, partners have collaborated together in an effort to reach a foundation of modernized educational/training courses on IoT to students and professionals. The identification of these methodologies and the analysis of previous experience among teachers involved in the development of the material was first completed (M3.1). A total of 21 projects for developing new teaching material on IoT was proposed, and teaching methodologies were selected for each of these projects (M3.4) that considered the use of the equipment and labs that are being built on each partner.