



Co-funded by the  
Erasmus+ Programme  
of the European Union



**Project:** Network of Competence on Internet of Things  
[NEON]

**Project ID:** 618942-EPP-1-2020-1-AT-EPPKA2-CBHE-JP

**Work Package 3:** Teaching methodologies, material and  
modernization of study programmes

**Title:** D3.3 Teaching and training materials for new and  
modernized IoT courses

**Lead Organization:** UNC

**Participating  
Organizations:** UNI-KLU, UC3M, UNC, UNS, UNMDP, UdelaR,  
UCU, INCUTEX, ALASSIO, ALENET

**Editors:** Jorge M. Finochietto

**Contributors:** Daniel Carrica, Favio Masson

**Disclaimer:**

"The European Commission support for the production of this publication does not constitute an endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein."

Deliverable data	Work Package and Outcome ref.nr	WP3 D3.2
	Title	Report on the modernized teaching methodologies applied to IoT courses
	Type	<input type="checkbox"/> Teaching material <input type="checkbox"/> Event <input type="checkbox"/> Learning material <input type="checkbox"/> Report <input type="checkbox"/> Training material <input type="checkbox"/> Service / Product
	Description	This report will show the teaching methodologies identified by teachers as more promising approaches for the IoT courses (MS3.1 and MS3.4). Furthermore, the document will describe which Latin American University will apply these methodologies in their study programmes.
	Date	01.04.2022
	Language	English
Target groups	<input checked="" type="checkbox"/> Teaching staff <input type="checkbox"/> Students <input type="checkbox"/> Trainees <input type="checkbox"/> Administrative staff <input checked="" type="checkbox"/> Technical staff <input type="checkbox"/> Librarians <input type="checkbox"/> Industry partners, Higher education authorities	
Dissemination level	<input type="checkbox"/> Department / Faculty <input type="checkbox"/> Local <input type="checkbox"/> National <input type="checkbox"/> Institution <input type="checkbox"/> Regional <input type="checkbox"/> International	
WP Lead Organization	UNC	
Participating Organizations	UNI-KLU, UC3M, UNC, UNS, UNMDP, UdelaR, UCU, INCUTEX, ALASSIO, ALENET	
Task	T3.3 Creation and / or modernization of teaching material related to IoT	

Revision History				
Version	Date	Author(s)	Organization(s)	Brief description of change
1	01.10.2022	Jorge M. Finochietto	UNC	Initial version
2	12.11.2023	Jorge M. Finochietto	UNC	Updated version with final material review

**Table of Contents**

<b>Introduction</b>	<b>5</b>
<b>Objectives of the Deliverable</b>	<b>5</b>
<b>Analysis of current adoption of innovative teaching methodologies</b>	<b>7</b>
<b>Identification of innovative teaching methodologies for IoT courses</b>	<b>Error! Bookmark not defined.</b>
<b>Selection of teaching methodologies for proposed IoT courses</b>	<b>Error! Bookmark not defined.</b>
<b>Conclusions</b>	<b>8</b>

## 1. Introduction

In order to train human resources, both in the academic field and in the public-private sphere, the NEON project has developed different teaching materials that can be used in courses targeting either undergraduate or graduate students as well as professionals through continuing education programs. Originally a total of 21 projects for developing these materials were identified as described in D3.2, where each project may be used in one or more courses or more than one project could contribute to a single course. These projects propose different teaching methodologies including flipped classroom, project-based learning, problem-based learning, collaborative learning, case study and experiential learning (i.e., hands on) through the use of the different laboratories that have been implemented in the framework of the Neon project. The material consists mainly of slide lessons, hand-on activities, video lectures, worksheets and quizzes. Most projects fall in the area of IoT Connectivity and Networks, and IoT Applications, while a few deal with IoT System Integration, IoT Hardware and IoT Data Analytics.

In this context, a set of courses where these materials will be delivered has been proposed in order to assess its impact when delivered. In the next sections, the development of the material for these courses is analyzed and described.

## 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 existing or new IoT courses. To this end the development of teaching material was proposed by partners in terms of projects that can be used to implement courses in different programs and degree levels. This deliverable aims at describing the different activities that were organized to monitor the development of the material and at analyzing its impact on the different programs from each partner when delivery is planned. To this end we

## 3. Development of the teaching material

The development of the teaching material started in mid 2021 and several activities were organized to monitor the progress and agree on common formats and methodologies. All these activities are described and reported on the Intranet of the project, inside the WP3 Meetings and Activities section.

As described in D3.1 a web repository was created to host all the materials and provide visibility of its progress as well as to collaborate with other partners in their development. An initial meeting was held on September 23, 2021, to discuss this and coordinate development activities on the material. In February 2022, two meetings related to the material development were virtually held. A first one on February 10, which was part of a plenary project meeting, helped to discuss and achieve common agreements on syllabus structures, common creative (CC) licenses and logos. A second meeting was organized virtually on February 24, where all teaching material projects were presented orally by each partner aiming to provide further details and foster collaboration.

In the following months the development of the projects was monitored by asking each partner to report on the status of their projects using different online surveys. A first survey was conducted in April 2022, which reported that:

- 1 project was completed (100%)
- 6 projects were almost completed (beyond 70%)

- 5 projects have more than 50% of development but less than 70%
- 6 projects have just started (between 30% and 50%)
- 3 projects were not reported, hence considered below 30% of development

A second survey was conducted during June 2022 to assess the progress of the material development which resulted in the following conclusions:

- 2 projects were completed (100%)
- 6 projects were almost completed (beyond 70%)
- 5 projects have more than 50% of development but less than 70%
- 5 projects have just started (between 30% and 50%)
- 3 projects were considered below 30% of development

A third survey and a virtual meeting was organized in October 2022 aiming at not only reviewing the material development but also the delivery of the developed material in different courses. A total of 20 courses using the proposed material have either been delivered by 2022 and/or planned to be delivered in 2023. In terms of these courses the level of development of the required material was reported as follows:

- 13 courses had all the required material developed (100%)
- 3 courses had almost all the required material developed (at least 70%)
- 2 courses had more than half of the material ready (more than 50% but less than 70%)
- 1 course had less than half of the material developed (but more than 30%)
- 1 course had not yet developed the material (0%)

Overall, if all 20 courses were considered, the average level of the development of the material was about 86%, and the remaining material was expected to be developed before mid 2023.

A fourth and final survey was conducted in April 2023 to update the development of the teaching material so as to close the development phase of the material. Even though most of the material was already completed, some authors requested some extension of a few weeks to achieve this task and declare its completion. By May 2023, all the material was uploaded to the web repository, eventually with minor updates in the following months.

After this survey, a review process was conducted in June 2023 where each material developed by one partner was reviewed by a different partner so as to assess the quality of the material before its public release. This review also analyzed the level of internationalization of the material in terms of the use of English. Results showed that less than 30% of the material is only available in Spanish, while the remaining includes some use of English. In particular, almost 40% uses mainly Spanish but also includes some English, while more than 30% is mainly in English (11.1%) or fully in English (22.3%).

All the teaching material was made publicly available in September 2023. The following table describes all 21 projects with the teaching material name and the partner involved in the development, and a public link to the repository.

#	Teaching Material (Partner)	Public Repository Link
1	Antenna Design (UDELAR)	<a href="https://github.com/neon-iot/antenna_design">https://github.com/neon-iot/antenna_design</a>
2	Digital Design for Low Power (UDELAR)	<a href="https://github.com/neon-iot/low-power">https://github.com/neon-iot/low-power</a>
3	Cellular IoT Systems (UNS)	<a href="https://github.com/neon-iot/cellulariotssystem">https://github.com/neon-iot/cellulariotssystem</a>

4	Fundamentals of communication systems (UNS)	<a href="https://github.com/neon-iot/fundamentalscomsys">https://github.com/neon-iot/fundamentalscomsys</a>
5	Introduction to digital communications (UNS)	<a href="https://github.com/neon-iot/introdigitalcom">https://github.com/neon-iot/introdigitalcom</a>
6	Antennas (UNS)	<a href="https://github.com/neon-iot/antennas">https://github.com/neon-iot/antennas</a>
7	Wireless Communications Systems (UNS)	<a href="https://github.com/neon-iot/wirelesscomm">https://github.com/neon-iot/wirelesscomm</a>
8	Real-time Embedded Systems (UDELAR)	<a href="https://github.com/neon-iot/embedded">https://github.com/neon-iot/embedded</a>
9	Wireless Sensor Networks (UDELAR)	<a href="https://github.com/neon-iot/wsn">https://github.com/neon-iot/wsn</a>
10	Communication Technologies for IoT (UDELAR)	<a href="https://github.com/neon-iot/communications">https://github.com/neon-iot/communications</a>
11	IoT Programming (UNC)	<a href="https://github.com/neon-iot/iotprogramming">https://github.com/neon-iot/iotprogramming</a>
12	Fundamentals of Internet of Things (UNC)	<a href="https://github.com/neon-iot/iotfundamentals">https://github.com/neon-iot/iotfundamentals</a>
13	Hands on IoT (UNMDP)	<a href="https://github.com/neon-iot/hands-on-iot">https://github.com/neon-iot/hands-on-iot</a>
14	Communications Labs (UNC)	<a href="https://github.com/neon-iot/communication_labs">https://github.com/neon-iot/communication_labs</a>
15	Cognitive Radio (UNC)	<a href="https://github.com/neon-iot/cognitive_radios">https://github.com/neon-iot/cognitive_radios</a>
16	Radio-localization and radar (UNS)	<a href="https://github.com/neon-iot/radioloc-radar">https://github.com/neon-iot/radioloc-radar</a>
17	IoT in Agribusiness (UCU)	<a href="https://github.com/neon-iot/iot4agro">https://github.com/neon-iot/iot4agro</a>
18	IoT Design and Embedded Systems (UCU)	<a href="https://github.com/neon-iot/iot_embebidos">https://github.com/neon-iot/iot_embebidos</a>
19	Fundamentals of Communication Systems (UCU)	<a href="https://github.com/neon-iot/sistemas_comunicaciones">https://github.com/neon-iot/sistemas_comunicaciones</a>
20	Communication Systems Based on Software Defined Radio (UNMDP)	<a href="https://github.com/neon-iot/sdrcomsys">https://github.com/neon-iot/sdrcomsys</a>
21	Hardware and Microwave Circuit design for IoT (UNMDP)	<a href="https://github.com/neon-iot/hwmwcircuitdesign">https://github.com/neon-iot/hwmwcircuitdesign</a>

#### 4. Impact of the teaching material

During the development of the teaching material, at least 20 courses were identified to be either modernized or created for the benefit of LA partners: 5 for UdeLaR, 3 for UCU, 3 for UNMDP, 3 for UNS, and 6 for UNC. A total of 9 courses corresponds to new ones, while the remaining 11, to existing ones which are being modernized. The total volume of these courses represents about 104 ECTS (103.7). Most of the courses (14) are part of undergraduate programs in engineering, but almost half of them (8) are part of graduate programs. Only a few of them (6) belong to continuing education programs. Note that a single course can be part of more than one program if accredited for so. All 11 existing courses being modernized have already been accredited, while for the 9 new ones, 5 have already been accredited while the remaining 4 are still in process. All these courses are planned to be delivered at least once by 2023: 13 of them have already been delivered, while 7 new courses are planned for 2023. The teaching material required for these courses has been developed since the start of the project, collaborative repositories ([github.com/neon-iot](https://github.com/neon-iot)) have been used for these purposes as described earlier.

A detailed table with the details for each of the 20 courses can be found in the project website and related deliverable. Herein, we report a summary where between brackets we indicate the number of ECTS, University, Undergraduate (UG)/Graduate (G)/Continuous Education (CE), Percentage of course development, New course accredited (NC)/Modernized course (MC), delivery semester: first semester (FS), second semester (SS):

1. Antenna Design (Diseño de Antenas) [3, Udelar, G/CE, 100%, NC, SS22/SS23]
2. Cellular IoT Technologies (Tecnologías celulares de IoT) [3.6, UNS, G, 100%, MC, SS22/SS23]
3. Cognitive Software Defined Radios (Radios Cognitivas Definidas por Software) [3.8, UNC, U, 100%, NC, SS22/SS23]
4. Communication Systems Based on Software Defined Radio (Sistemas de Comunicaciones basados en radio Definida por Software) [7.7, UNMDP, U, 80%, NC, FS23]
5. Computer Programming (Informática) [5, UNC, U, 50%, MC, FS23]
6. Digital Communications (Comunicaciones Digitales) [5.1, UNC, U, 100%, MC, FS22/FS23]
7. Fundamentals of Communication Systems (Fundamentos de los Sistemas de Comunicación) [6, UCU, U, 100%, MC, FS22/ FS23]
8. Fundamentals of Communication Systems (Fundamentos de Sistemas de Comunicaciones) [7.7, UNS, U, 80%, MC, FS23/SS23]
9. Hands on IoT (Diseño y aplicaciones con tecnologías IoT) [2, UNMDP, U, 100%, NC, SS22/FS23]
10. Hardware and Microwave Circuit design for IoT [7.8, UNMDP, U, 80%, NC, FS23]
11. Internet of Things (Internet de las Cosas) [4.3, UNC, U, 70%, NC, SS23]
12. Introduction to Digital Communications (Introducción a las comunicaciones digitales) [7.7, UNC, U, 60%, MC, SS23]
13. IoT Design and Embedded Systems (Diseño de IoT y Sistemas Embebidos) [8, UCU, U, 0%, MC, FS23]
14. IoT in Agribusiness (IoT para la Agroindustria) [6, UCU, U, 100%, NC, FS22/FS23]
15. Low-power digital design (diseño digital de bajo consumo) [4.8, Udelar, G/CE, 100%, MC, SS22/SS23]
16. Real Time Embedded Systems (Sistemas Embebidos para Tiempo Real) [6, Udelar, U/G/CE, 100%, MC, FS22/FS23]
17. Remote SDR Lab (Laboratorio remoto de radio definidas por software) [0.4, UNC, CE, 100%, NC, SS22/SS23]
18. Communication technologies for IoT (Tecnologías para IoT) [3.6, Udelar, G/CE, 100%, MC, FS22/FS23]
19. Wireless Communications (Comunicaciones Inalámbricas) [6.4, UNC, G, 100%, NC, SS22]
20. Wireless sensor networks (Redes de sensores inalámbricos) [4.8, Udelar, U/G/CE, 100%, MC, SS22/SS23]

## 5. Conclusions

As described throughout this document, the development of teaching material was carried out successfully from mid 2021 to mid 2023. All partners actively worked in this task, participating in activities and meetings that were proposed to accomplish this goal on time. A total of 20 courses will benefit from this effort, some of these courses have already been delivered by 2022 and all of them are planned to be delivered by 2023.