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| 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: | D3.4 Delivery of teaching and training classes 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 |
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| Deliverable data | Work Package and Outcome ref.nr | WP3 D3.4 |
| | Title | Report on the modernized teaching methodologies applied to IoT courses |
| | Type | ☐ Teaching material ☐ Event<br>☐ Learning material ☐ Report<br>☐ Training material ☒ Service / Product |
| | Description | Teaching classes on IoT topics will be delivered in parallel at each Latin American institution for new under-graduate and graduate courses.<br>The teaching modes will include face-to-face, on-line and blended learning. Teaching classes will also consider the industry needs related to<br>the working methodology. The course material will be written in the local language and partially in English to enhance internationalization. |
| | Date | 01.04.2022 |
| | Language | Spanish and English |
| Target groups | ☒ Teaching staff<br>☒ Students<br>☒ Trainees<br>☐ Administrative staff<br>☐ Technical staff<br>☐ Librarians<br>☐ Industry partners, Higher education authorities | |
| Dissemination level | ☐ Department / Faculty ☐ Local ☒ National<br>☐ Institution ☒ Regional ☐ International | |
| WP Lead Organization | UNC | |
| Participating Organizations | UNI-KLU, UC3M, UNC, UNS, UNMDP, UdelaR, UCU, INCUTEX, ALASSIO, ALENET | |
| Task | T3.3 Improvement and implementation of new learning/teaching methods, tools, ICT best practices in teaching | |

| Revision History | | | | |
|---|---|---|---|---|
| Version | Date | Author(s) | Organization(s) | Brief description of change |
| 1 | 01.11.2023 | Jorge M. Finochietto | UNC | First version |

**Table of Contents**

# 1. Introduction

In order to train human resources, both in the academic field and in the public-private sphere, the NEON project developed different teaching materials to be used in courses targeting either undergraduate or graduate students as well as professionals through continuing education programs. A total of 21 teaching material projects were developed and the resulting material was made publicly available to be used in different courses. Each project targeted one or more courses. These projects proposed 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 developed material consists mainly of slide lessons, hand-on activities, video lectures, worksheets and quizzes. Most projects fell 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 total of 27 courses were proposed to be delivered using the developed material. The delivery period was during the project timeline (2021-2023), resulting in a total of 47 deliveries that reached 1037 students distributed in 5 universities (UCU, UDELAR, UNC, UNMDP, UNS).

# 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 delivery actions that were performed by partners based on the material that was developed. It also discusses main results from these actions in terms of impact on the different institutions and also on the implementation of modern teaching methodologies.

# 3. Delivery of the teaching material

A total of 47 delivery actions were carried out, which corresponded to a total of 27 courses that used the teaching material developed in 21 projects. The following table summarizes the actions carried by each partner considering the amount of teaching material projects completed (Repositories) and the number of courses that were proposed based on these projects. It also describes the main aggregate results from these actions in terms of the deliveries count, the total hours, and the total students. In particular:

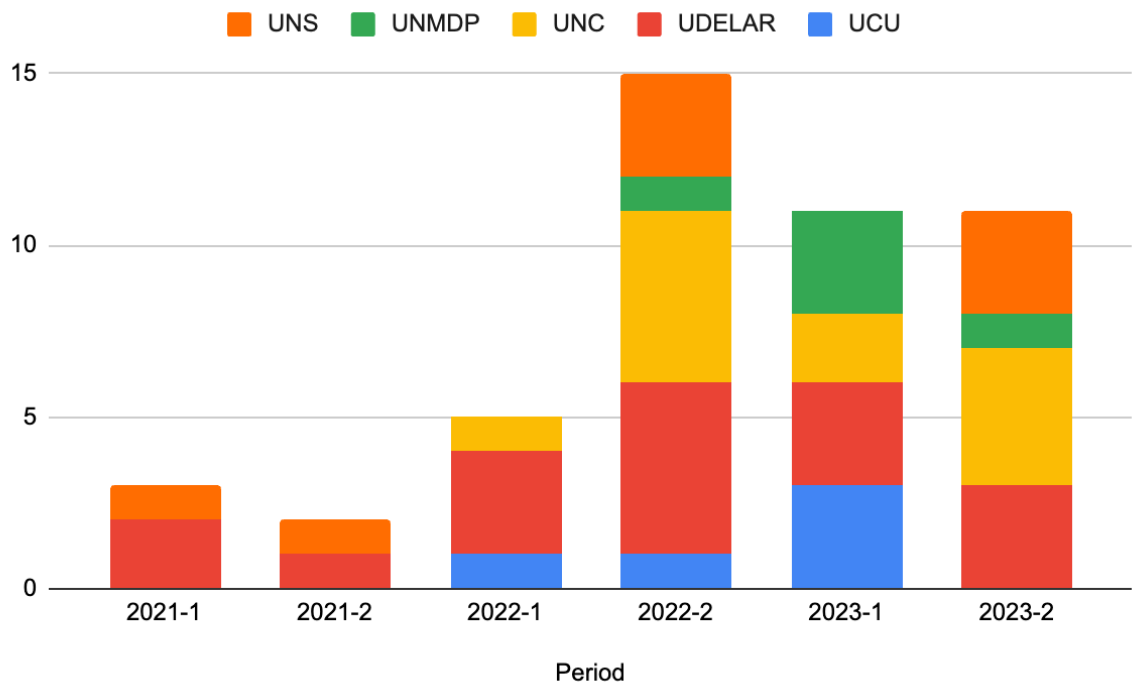
- **Repositories** indicate the number of teaching material projects developed by the partner, where each one at least is used by one course for its delivery.
- **Deliveries** account for the amount of delivery actions done by the partner. It considers the total number a course was taught. If a course has been taught more than once, then each instance is counted.
- **Hours** considers the total number of hours of all delivery actions by the partner. These hours include not only direct lecturing but also those out of class by students.
- **Students** consider the amount of students that have been enrolled in the delivered courses.

| # | Partner | Repositories | Courses | Deliveries | Hours | Students |
|---|---|---|---|---|---|---|
| 1 | UCU | 3 | 3 | 5 | 700 | 66 |
| 2 | UDELAR | 5 | 5 | 17 | 1620 | 207 |
| 3 | UNC | 4 | 8 | 12 | 838 | 629 |
| 4 | UNMDP | 3 | 4 | 5 | 488 | 90 |
| 5 | UNS | 6 | 7 | 8 | 760 | 45 |
| | **Totals** | **21** | **27** | **47** | **4406** | **1037** |

From this table the impact of the 47 delivery actions can be evaluated. In particular the fact that 4406 hours were completed and 1037 students were reached illustrates the main results of the delivery phase. The fact that the amount of deliveries almost doubled the number of courses also highlights that some courses were taught more than once during the duration of the project.

The delivery of the teaching material was carried out during the project span, from beginning 2021 to the end of 2023. Since academic years are organized in semester, a first year semester considers the delivery between march and june, while a second semester, from august to november. It is worth noticing that in the southern hemisphere the academic year starts in February and ends in december. The table below shows the amount of deliveries per semester, which is also illustrated in the figure below the table.

| Period | Deliveries | UCU | UDELAR | UNC | UNMDP | UNS |
|---|---|---|---|---|---|---|
| 2021-1 | 3 | 0 | 2 | 0 | 0 | 1 |
| 2021-2 | 2 | 0 | 1 | 0 | 0 | 1 |
| 2022-1 | 5 | 1 | 3 | 1 | 0 | 0 |
| 2022-2 | 15 | 1 | 5 | 5 | 1 | 3 |
| 2023-1 | 11 | 3 | 3 | 2 | 3 | 0 |
| 2023-2 | 11 | 0 | 3 | 4 | 1 | 3 |
| **Totals** | **47** | **5** | **17** | **12** | **5** | **8** |




A more detailed description is shown in the table below which illustrates the results but considering each developed project (Repository). Even if each teaching material typically targeted a single course, some projects were used in more than one course. The table provides information on the amount of courses, deliveries, hours, and students (S).

| # | Repository | Courses | Deliveries | Hours | Students |
|---|---|---|---|---|---|
| 1 | Antenna Design (UDELAR) | 1 | 2 | 150 | 19 |
| 2 | Hands on IoT (UNMDP) | 1 | 2 | 120 | 61 |
| 3 | Communication Systems Based on Software Defined Radio (UNMDP) | 2 | 2 | 296 | 19 |
| 4 | IoT in Agribusiness (UCU) | 1 | 2 | 200 | 27 |
| 5 | Fundamentals of Communication Systems (UCU) | 1 | 2 | 300 | 28 |
| 6 | IoT Design and Embedded Systems (UCU) | 1 | 1 | 200 | 11 |
| 7 | Fundamentals of communication systems (UNS) | 1 | 1 | 120 | 15 |
| 8 | Cellular IoT Systems (UNS) | 1 | 3 | 240 | 12 |
| 9 | Radio-localization and radar (UNS) | 2 | 3 | 320 | 13 |
| 10 | Wireless Communications Systems (UNS) | 1 | 1 | 80 | 5 |
| 11 | IoT Programming (UNC) | 1 | 1 | 126 | 118 |
| 12 | Fundamentals of Internet of Things (UNC) | 3 | 3 | 60 | 376 |
| 13 | Wireless Sensor Networks (UDELAR) | 1 | 5 | 600 | 55 |
| 14 | Communication Technologies for IoT (UDELAR) | 1 | 2 | 180 | 8 |

| | | | | | |
|---|---|---|---|---|---|
| 15 | Digital Design for Low Power (UDELAR) | 1 | 2 | 240 | 4 |
| 16 | Real-time Embedded Systems (UDELAR) | 1 | 6 | 450 | 121 |
| 17 | Communications Labs (UNC) | 3 | 5 | 448 | 124 |
| 18 | Cognitive Radio (UNC) | 1 | 3 | 204 | 11 |
| 19 | Hardware and Microwave Circuit design for IoT (UNMDP) | 1 | 1 | 72 | 10 |
| 20 | Introduction to digital communications (UNS) | 1 | - | - | - |
| 21 | Antennas (UNS) | 1 | - | - | - |
| | **Totals** | **27** | **47** | **4406** | **1037** |

From this table it can be appreciated that almost all developed material in each repository was used to deliver a single course. Indeed, 23 repositories are associated to a single course, while 2 of them to 2 courses, and the remaining 2, to 3 courses. Since the table also indicates the delivery actions linked to the teaching material, it is also possible to observe that 2 projects have no delivery actions. The reason for this is that the courses have no students enrolled, hence, not being able to deliver the developed material.

Finally, the following table describes the results from each course that was delivered, including not only the delivery count, the total number of hours and students, but also the number of academic programs associated with the course and the amount of teachers involved in its delivery.

| # | Course | Deliveries | Hours | Programs | Students | Teachers |
|---|---|---|---|---|---|---|
| 1 | Antenna Design | 2 | 150 | 3 | 19 | 3 |
| 2 | Hands on IoT | 2 | 120 | 2 | 61 | 4 |
| 3 | Communication Systems based on Software Defined Radio | 1 | 96 | 2 | 4 | 3 |
| 4 | IoT in Agribusiness | 2 | 200 | 5 | 27 | 9 |
| 5 | Fundamentos de Comunicacion | 2 | 300 | 3 | 28 | 1 |
| 6 | Diseño de IoT y Sistemas Embebidos | 1 | 200 | 3 | 11 | 3 |
| 7 | Fundamentos de Sistemas de Comunicaciones | 1 | 120 | 1 | 15 | 3 |
| 8 | Tecnologías celulares de IoT | 3 | 240 | 2 | 12 | 3 |
| 9 | Radio-localización y Radares | 2 | 240 | 2 | 5 | 1 |
| 10 | Sistemas de Comunicaciones Inalámbricas | 1 | 80 | 2 | 5 | 1 |
| 11 | Posicionamiento y Seguimiento | 1 | 80 | 2 | 8 | 1 |
| 12 | Informática | 1 | 126 | 8 | 118 | 1 |
| 13 | Dispositivos IoT | 1 | 20 | 0 | 231 | 7 |
| 14 | Conectividad y Protocolos IoT | 1 | 20 | 0 | 81 | 7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 15 | Aplicaciones y Visualización en IoT | 1 | 20 | 0 | 64 | 7 |
| 16 | Redes de Sensores Inalámbricos | 5 | 600 | 4 | 55 | 5 |
| 17 | Tecnologías para la Internet de las Cosas | 2 | 180 | 4 | 8 | 5 |
| 18 | Diseño digital de bajo consumo | 2 | 240 | 5 | 4 | 8 |
| 19 | Sistemas Embebidos para Tiempo Real | 6 | 450 | 6 | 121 | 8 |
| 20 | Comunicaciones Digitales | 2 | 188 | 5 | 110 | 3 |
| 21 | Radios cognitivas definidas por software | 3 | 204 | 6 | 11 | 3 |
| 22 | Experimentando en un Laboratorio Remoto de Radio Definida por Software. Caso de Aplicación: Modulación LORA | 1 | 20 | 3 | 6 | 2 |
| 23 | Comunicaciones Inalámbricas | 2 | 240 | 2 | 8 | 2 |
| 24 | Hardware and Microwave Circuit design for IoT | 1 | 72 | 1 | 10 | 2 |
| 25 | Medios de Transmisión | 1 | 200 | 1 | 15 | 4 |
| 26 | Introducción a las Comunicaciones Digitales | 0 | - | - | - | - |
| 27 | Antenas | 0 | - | - | - | - |
| | | **47** | **4406** | **-** | **1037** | **96** |

In general, it can be noted that most courses have an impact on more than one academic program, and more than one teacher was involved in its delivery.

# 4. Impact of the delivery actions

Different types of evidence of the delivery actions were also collected. Most courses had a formal enrollment procedure from their institution which provides information about the program and the amount of students that took the course. Another used tool to not only account for the participation of students but also evaluate the course was a survey. Besides, several courses included video lecturing, which provides recordings from classes, and pictures.

- Enrolments: 22 (88%)
- Survey: 11 (42.3%)
- Recording: 9 (36%)

| # | Course | Recordings | Enrolment | Survey | Other |
|---|---|---|---|---|---|
| 1 | Antenna Design | **1** | **1** | **1** | **0** |

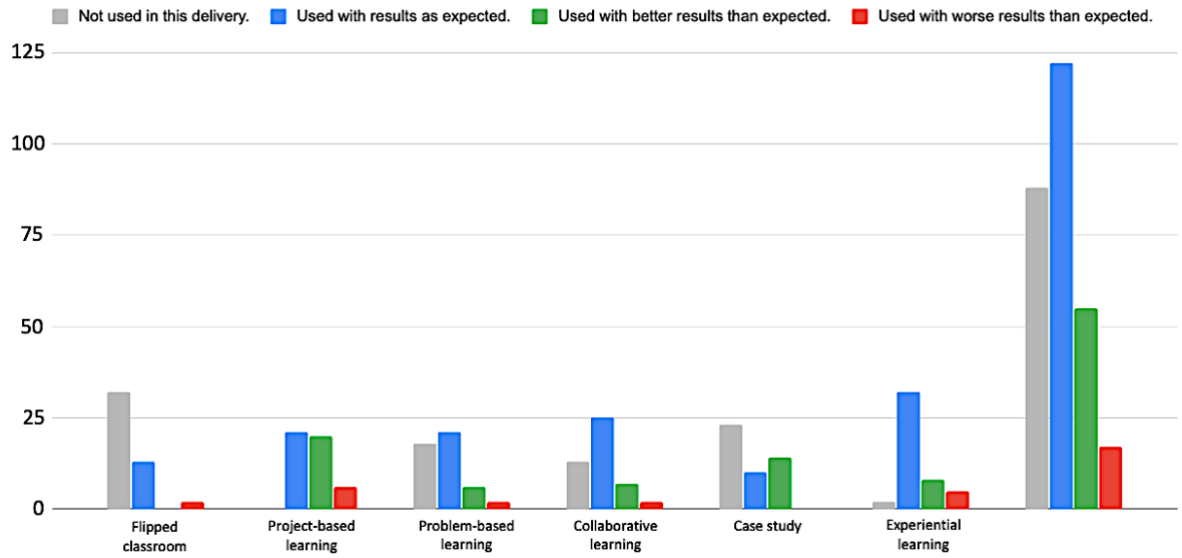
| | | | | | |
|---|---|---|---|---|---|
| 2 | Hands on IoT | **1** | **1** | **1** | **0** |
| 3 | Communication Systems based on Software Defined Radio | **0** | **1** | **1** | **0** |
| 4 | IoT in Agribusiness | **0** | **1** | **1** | **0** |
| 5 | Fundamentos de Comunicación | **0** | **1** | **0** | **0** |
| 6 | Diseño de IoT y Sistemas Embebidos | **0** | **1** | **0** | **0** |
| 7 | Fundamentos de Sistemas de Comunicaciones | **0** | **1** | **0** | **0** |
| 8 | Tecnologías celulares de IoT | **1** | **1** | **1** | **0** |
| 9 | Radio-localización y Radares | **0** | **1** | **0** | **0** |
| 10 | Sistemas de Comunicaciones Inalámbricas | **0** | **1** | **0** | **0** |
| 11 | Posicionamiento y Seguimiento | **0** | **1** | **0** | **0** |
| 12 | Informática | **1** | **1** | **1** | **0** |
| 13 | Dispositivos IoT | **1** | **1** | **1** | **0** |
| 14 | Conectividad y Protocolos IoT | **1** | **1** | **1** | **0** |
| 15 | Aplicaciones y Visualización en IoT | **1** | **1** | **0** | **0** |
| 16 | Redes de Sensores Inalámbricos | **0** | **1** | **0** | **0** |
| 17 | Tecnologías para la Internet de las Cosas | **0** | **1** | **0** | **0** |
| 18 | Diseño digital de bajo consumo | **0** | **1** | **1** | **0** |
| 19 | Sistemas Embebidos para Tiempo Real | **0** | **1** | **0** | **0** |
| 20 | Comunicaciones Digitales | **1** | **1** | **0** | **0** |
| 21 | Radios cognitivas definidas por software | **0** | **0** | **1** | **0** |
| 22 | Experimentando en un Laboratorio Remoto de Radio Definida por Software. Caso de Aplicación: Modulación LORA | **0** | **0** | **0** | **1** |
| 23 | Comunicaciones Inalámbricas | **0** | **0** | **1** | **0** |
| 24 | Hardware and Microwave Circuit design for IoT | **1** | **1** | **0** | **0** |
| 25 | Medios de Transmisión | **0** | **1** | **0** | **0** |
| | | **9** | **22** | **11** | **1** |

A general assessment on the teaching methodologies was also carried out, with the following results:

- All courses implemented Project-based learning
- Most courses (+95%) integrated hands-on activities
- Flipped classroom was the least used
- In general results were as expected or even better

The following table describes in detail main outcomes for each methodology:

| Teaching Methodology | Reported Actions | Used with results as expected. | Used with better results than expected. | Used with worse results than expected. |
|---|---|---|---|---|
| Flipped classroom | 31.9% | 86.67% | 0.00% | 13.33% |
| Project-based learning | 100.0% | 44.68% | 42.55% | 12.77% |
| Problem-based learning | 61.7% | 72.41% | 20.69% | 6.90% |
| Collaborative learning | 72.3% | 73.53% | 20.59% | 5.88% |
| Case study | 51.1% | 41.67% | 58.33% | 0.00% |
| Experiential learning | 95.7% | 71.11% | 17.78% | 11.11% |




## 5. Conclusions

As described throughout this document, the development of teaching material was completed successfully and led to the delivery of multiple courses. All partners have actively worked in this task, totalizing 47 delivery actions composed of 27 different courses. More than thousand students participated in these actions, involving a significant amount of teachers and academic programs during the duration of the project. These actions also helped to better assess the value of modern teaching methodologies, where both project-based learning and hands-on activities resulted in the most used and with better results.