

# CONSTRUCTION OF STRUCTURES I IN MOODLE: A NEW TEACHING METHODOLOGY IN THE DEGREE OF BUILDING ENGINEER

**Beatriz Piedecausa Garcia, Juan Carlos Pérez Sánchez**

*Department of Building and Urban Planning. University of Alicante (SPAIN)*

## Abstract

The subject of Construction of Structures I studies, from a constructive point of view and taking into account current legislation, reinforced concrete structures used in buildings, through the acquisition of knowledge and construction criteria required in the profession of a Building Engineer.

The contents acquired in this course are essential for further professional development of technicians and are closely related to many of the subjects taught in the same or other courses of the Degree in Building Engineer at the University of Alicante. The most important specific skills are acquired in a practical way by solving real professional construction details and exercises that allow the identification and selection of the most suitable constructive elements or building systems, their compatibility conditions and their work control.

The aim of this paper is to present, analyze and discuss the development of a new methodology proposed in the mentioned subject, as it supposed an important change in the traditional way of teaching Construction of Structures I.

In order to incorporate new teaching tools in 2013-2014, the course has been implemented by using a Moodle software tool to promote blended learning with online exercises. Our Moodle community allows collaborative work within an open-source platform where teachers and students share a new and personalized learning environment. Students are easily used to the interface and the platform, valuing the constant connection with teachers or other fellows and completely agree with the possibility of making questions or share documents 24 hours a day.

The proposed methodology consists of lectures and practical classes. In the lectures, the basics of each topic are discussed; class attendance, daily study and conducting scheduled exercises are indispensable. Practical classes allow to consolidate the knowledge gained in theory classes by solving professional exercises and actual construction problems related to structures, that shall be compulsorily delivered online. So, after the correction of the teacher and the subsequent feedback of students, practical exercises ensure lifelong learning of the student, who can download any kind of material at any time (constructive details, practical exercises and even corrected exams).

Regarding the general evaluation system, goals achievement is assessed on an ongoing basis (65% of the final mark) along the course through written and graphic evidences in person and online, as well as a individual development of a workbook. In all cases, the acquisition of skills, the ability to synthesize, the capacity of logical and critical thinking and the ability to show an orderly transmission of information are assessed. The other 35 % of the mark is evaluated by a complementary graphic exam.

Participation in the computing platform is essential and the student is required to do and present, in each specific date, at least 90% of the practices proposed. Those who do not comply with the practices in their respective days could not be assessed continuously and may only choose the final exam.

In conclusion, the subject of Construction of Structures I is essential for the development of the regulated profession of Building Engineer as they are considered, among other professional profiles, as specialists in construction of building structures. The use of a new communication platform and online teaching allows the acquisition of knowledge and constructive approaches in a continuous way, with a more direct and personal monitoring by the teacher that has been highly appreciated by almost 100% of the students. Ultimately, it is important to say that the use of Moodle in this subject is a very interesting tool, which was really well welcomed by students in one of the densest and important subjects of the Degree of Building Engineer.

Keywords: Construction, structures, moodle, Building Engineer.

## 1 INTRODUCTION

In the last years, the construction sector has been characterized by significant policy changes since the approval of a new Technical Building Code (CTE\_Código Técnico de la Edificación), the compulsory law for Energy Efficiency and the Instruction for Structural Concrete (EHE- 08 Instrucción de hormigón estructural) [1] among others.

The application of these new rules leads to an important increase of the control required in different areas: on the one hand, in the documentary requirements of construction projects; on the other, in the control of building works. In both cases, today there is a considerable increase of the users' and society's exigencies, demanding buildings with better performance and higher construction quality. This situation raises the need for new educational requirements in the training of future professionals, assuming a change of great importance in the professional practice of Building Engineer.

From the university level, the introduction of new degrees adapted to the structure of ECTS credits given by European Higher Education Area (EHEA) derived into a major revision of the old learning curriculum of Building Engineer.

In the specific case of the subject studied in this paper, Construction of Structures I, the analysis of the experience of recent years has redefined new teaching methodologies. This is a key subject in the development of the regulated profession of Technical Architects to be considered, among other profiles, as a specialist in the construction of building structures. Thus, taking into account the previous experience in time, the subject adaptation allows a new opportunity to design it ex novo, to fit more specifically to the requirements of the EHEA.

## 2 STUDY PROPOSED

### 2.1 Scope

Assuming that the Building Engineer is specialized in construction of building structures, the subject of Construction of Structures I is essential for the further development of the profession, and that is why it is related to almost all the subjects of the Degree in Building Engineer.

The subject has 6 ECTS credits and belongs to the Construction Area of the Department of Building and Urban Planning of the Polytechnic School, and its programme contains several chapters of reinforced concrete structures used in buildings from the point of view of construction, making the student to acquire the knowledge and the necessary constructive criteria for the future profession.

During the 2013/2014 year, 205 students have enrolled the subject divided into 5 groups and in Theoretical and Practical Seminars (4 groups in Spanish and one group in Catalan).

### 2.2 Objectives

The aim of this paper is to analyze and discuss the development of a new teaching methodology as an alternative to traditional teaching in the subject of Construction of Structures I of the Degree in Building Engineer from the University of Alicante since, in the 2013-2014 year, Moodle has been implemented as a tool to promote combined learning with online exercises that reinforce the acquisition of specific skills.

The subject is part of the compulsory subjects of the second year of the Degree in Building Engineer and is taught in the first semester. During the development of the course, reinforced concrete structures used in buildings are studied from the point of view of the construction, keeping in mind the current regulations, in order to acquire constructive criteria for the future development of the profession as general information on concrete and steel, classification of reinforcements, etc.

The specific objectives in the course are:

- To arise student interest in general construction and in the particular content of the course.
- To understand the systems in building structures, their constitution, foundations, uses, way of working and to make the best choice in every situation.
- To learn, analyze and reason the process of execution in each building system, taking into account the behaviour of materials and working methods of the components, in order to be able to develop and solve the various problems that may arise in the future.

- To know and apply the regulations of each building system studied.
- To draw different constructive solutions in a clear and rigorous way, acquiring skills that allow the student to define and solve problems and construction details related to building structures [2,3,4,5]

During the teaching process, the acquisition of General Transversal Competencies is also considered (specifically referred to as G12: computer and information skills) by using the software tool Moodle [6,7,8].

### 3 METHODOLOGY

The educational work has enabled the design of the themes in the subject according to several factors: those required by regulatory agencies of education which define credits (6 ECTS) and a specific agenda to teach that is considered in table 1, divided into five different blocks:

- The first block is dedicated to generalities of reinforced concrete and armours.
- In the second block shallow foundations are studied.
- In the third block aspects of deep foundations are explained.
- The fourth is devoted to the various types of existing walls.
- Finally, we have reserved a fifth block for slabs.

This distribution aims to achieve a progressive acquisition of skills through the practical application of knowledge that refer to theoretical issues through the attendance to practical classes and continuous active student participation, especially by valuing the positive development of the students throughout the course.

The teaching methodology is proposed combining theoretical and practical sessions, supported by the software tool in a continuous way (Fig.1). As far as possible, there will be visits to works throughout the course.

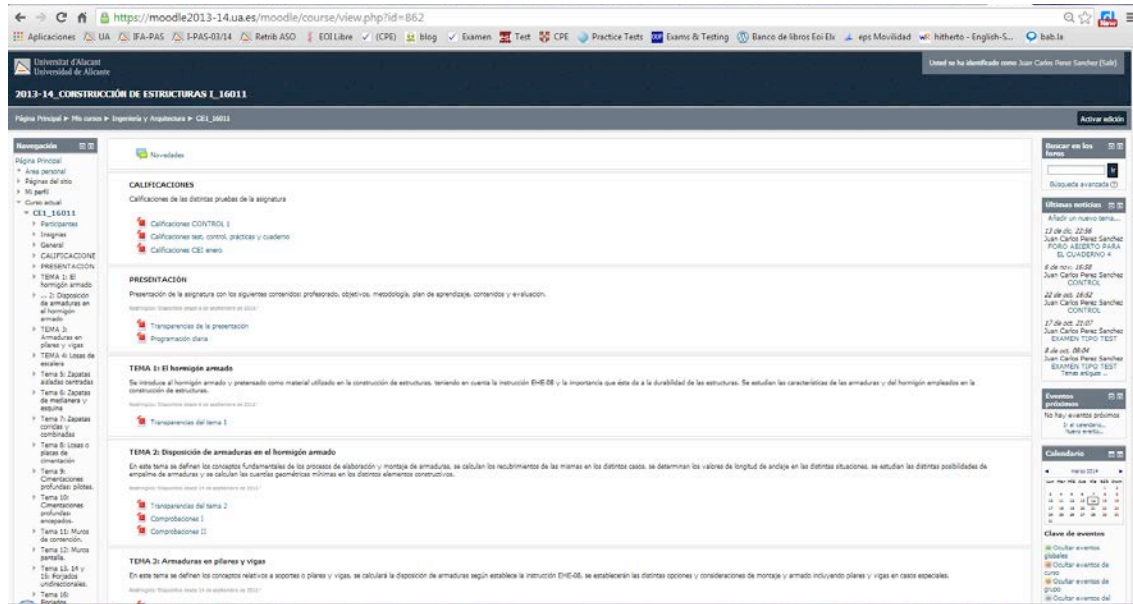


Figure 1. Appearance of the online platform (Moodle).

In the lectures, the basis of each topic are presented using various audiovisual media in the classroom. The exposure of different themes will follow the order of the course manuals. Class attendance, daily study of the subject taught and the conduct of exercises is essential to successfully achieve the main objectives. In the programmed timetable of the course it can be seen the distribution of expositions throughout the academic year.

Practical classes will serve to consolidate the knowledge acquired in lectures. The practices will be proposed in class and will consist on exercises and construction problems related with structures.

Constructive solutions proposed have to be drawn in an orderly, accurate and reliable way. These practices will be delivered and corrected by the teacher, so as to enable student learning in person and online.

Recent years in the construction sector have been characterized by significant changes towards a new regulatory framework, leading to a significant increase of the documentary requirements of construction projects and control of work as a great importance in the practice of the Degree in Building Engineer. In this new context, the desirability of the use of current computer tools that complement the theoretical knowledge of basic concepts and critical analysis of student evidence is needed. Thus, this course has been considered with a theoretical practice which is complemented by a large number of non-presential hours with online tracking through the platform (Table 1).

Table1. Types of activities in the year 2013-14.

TEACHING	CLASSROOM HOURS	NON CLASSROOM HOURS
THEORETICAL AND PRACTICAL SEMINAR	60	90
TOTAL	60	90

#### 4 RESULTS

Due to the different knowledge and background of students, both about the theoretical content of the course and about the software used, different practices are designed so that the knowledge gained is gradual and successive, securing the required results.

Using this platform enables to secure the acquisition of theoretical knowledge by solving real professional construction details and exercises related to structures. Thus, after the correction of the exercises by the professor and the subsequent feedback from students, the practices ensure students' lifelong learning, thanks to the easy download of different materials (construction details, practical exercises and corrected exams) at any time [9,10] (Fig.2).

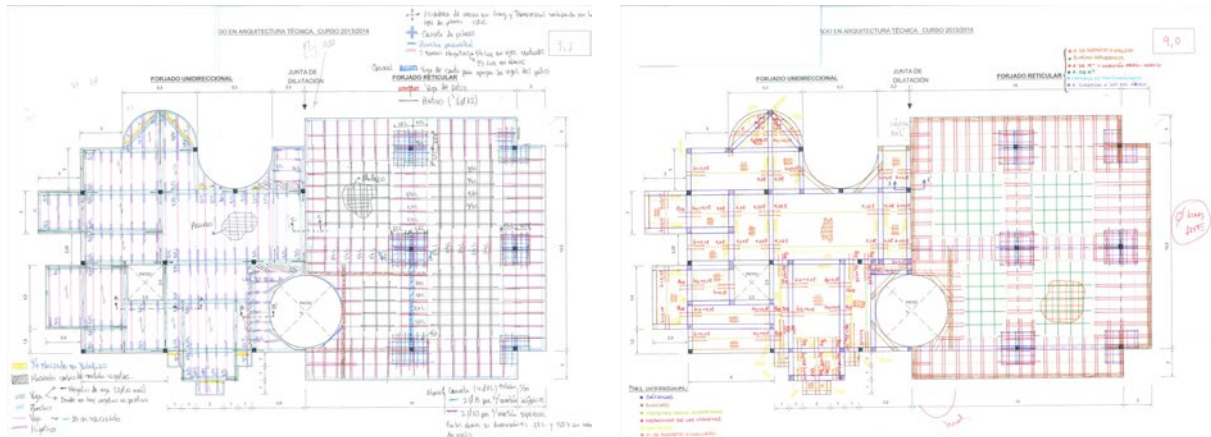


Figure 2. Example of some exercises done by students and posted in the Moodle platform.

Setting weekly goals on practical work throughout the course improves student participation and continued learning (Fig.3), ensuring a continuous development of the exercises in time, delivered in the planned date and achieving the proposed quality objectives.

CONSTRUCCIÓN DE ESTRUCTURAS I					
Grado en Ingeniería de Edificación. Curso 2013-14					
TEORÍA Y PRÁCTICA					
Grupo	1	2	3	4	5
Profesores	Juan C. Pérez	Juan C. Pérez	Raquel Sánchez	Raquel Sánchez	Vicente Gomis
Horario	M 12:30-14:30 h V 12:30-14:30 h	M 10:30-12:30 h V 09:30-12:30 h	L 19:00-21:00 h J 19:00-21:00 h	L 15:00-17:00 h J 15:00-17:00 h	X 17:00-19:00 h J 17:00-19:00 h
Tema previsto    Tema previsto    Tema previsto    Tema previsto    Tema previsto					
1	L 09-sep M 10-sep X 11-sep J 12-sep V 13-sep L 14-sep M 15-sep	Presentation Presentation			
2	L 17-sep M 18-sep X 19-sep J 20-sep V 21-sep L 22-sep M 23-sep	Tema 1 Tema 2 Tema 3 Tema 4	Tema 1 Tema 2 Tema 3 Tema 4	Tema 1 Tema 2 Tema 3 Tema 4	Tema 1 Tema 2 Tema 3 Tema 4
3	L 25-sep M 26-sep X 27-sep J 28-sep V 29-sep L 30-sep M 01-oct	Práctica 1 Práctica 1 Práctica 1	Práctica 1 Práctica 1 Práctica 2	Práctica 1 Práctica 2 Práctica 2	Práctica 1 Práctica 1 Práctica 2-3
4	L 03-oct M 04-oct X 05-oct J 06-oct V 07-oct L 08-oct M 09-oct	Práctica 3 Práctica 3 Práctica 3	Práctica 3 Práctica 3 Práctica 3	Práctica 3 Práctica 3 Práctica 3	Práctica 3-3 Práctica 3 Práctica 3 Práctica 3 Práctica 3
5	L 10-oct M 11-oct X 12-oct J 13-oct V 14-oct L 15-oct M 16-oct	Corrección Corrección Corrección	Corrección Corrección Corrección	Corrección Corrección Corrección	Corrección Corrección Corrección
6	L 18-oct M 19-oct X 20-oct J 21-oct V 22-oct L 23-oct M 24-oct	Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6	Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6	Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6	Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6 Tema 5 y 6
7	L 26-oct M 27-oct X 28-oct J 29-oct V 30-oct L 31-oct M 01-nov	Tema 12 Tema 12 Tema 12 Tema 12 Tema 12 Tema 12 Tema 12	Tema 12 Tema 12 Tema 12 Tema 12 Tema 12 Tema 12 Tema 12	Tema 12 Tema 12 Tema 12 Tema 12 Tema 12 Tema 12 Tema 12	Tema 12 Tema 12 Tema 12 Tema 12 Tema 12 Tema 12 Tema 12
8	L 03-nov M 04-nov X 05-nov J 06-nov V 07-nov L 08-nov M 09-nov	Práctica 4 Práctica 4 Práctica 4 Práctica 4 Práctica 4 Práctica 4 Práctica 4	Práctica 4 Práctica 4 Práctica 4 Práctica 4 Práctica 4 Práctica 4 Práctica 4	Práctica 4 Práctica 4 Práctica 4 Práctica 4 Práctica 4 Práctica 4 Práctica 4	Práctica 4 Práctica 4 Práctica 4 Práctica 4 Práctica 4 Práctica 4 Práctica 4
9	L 11-nov M 12-nov X 13-nov J 14-nov V 15-nov L 16-nov M 17-nov	Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6	Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6	Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6	Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6 Práctica 5 y 6
Corrección    Corrección    Corrección    Corrección    Corrección					

		09-nov					
		10-nov					
10	L	11-nov			CONTROL	CONTROL	CONTROL
	M	12-nov			CONTROL	CONTROL	CONTROL
	X	13-nov			CONTROL	CONTROL	CONTROL
	J	14-nov					
	V	15-nov	Tema 13 y 14.1	Tema 13 y 14.1	Tema 13 y 14.1	Tema 13 y 14.1	Tema 13 y 14.1
	L	16-nov					
	M	17-nov					
	X	18-nov	Tema 14.2 y 15	Tema 14.2 y 15	Tema 14.2 y 15	Tema 14.2 y 15	Tema 14.2 y 15
	J	19-nov					
	V	20-nov	Tema 15-1	Tema 15-1	Tema 15-1	Tema 15-1	Tema 15-1
	L	21-nov					
	M	22-nov					
	X	23-nov					
	J	24-nov					
	V	25-nov	Tema 16.2 y 17	Tema 16.2 y 17	Tema 16.2 y 17	Tema 16.2 y 17	Tema 16.2 y 17
	L	26-nov					
	M	27-nov					
	X	28-nov	Práctica 7	Práctica 7	Práctica 7	Práctica 7	Práctica 7
	J	29-nov					
	V	30-nov					
	L	01-dic					
	M	02-dic	Práctica 8 y 9	Práctica 8 y 9	Práctica 8	Práctica 8	Práctica 8
	X	03-dic					
	J	04-dic					
	V	05-dic					
	L	06-dic					
	M	07-dic					
	X	08-dic					
	J	09-dic	Práctica 10	Práctica 10	Práctica 10	Práctica 10	Práctica 10
	V	10-dic					
	L	11-dic					
	M	12-dic	Corrección	Corrección	Corrección	Corrección	Corrección
	X	13-dic					
	J	14-dic					
	V	15-dic					
	L	16-dic					
	M	17-dic	Entrega trabajo	Entrega trabajo	Entrega trabajo	Entrega trabajo	Entrega trabajo
	X	18-dic					
	J	19-dic					
	V	20-dic	Entrega trabajo	Entrega trabajo	Entrega trabajo	Entrega trabajo	Entrega trabajo
	L	21-dic					
	M	22-dic					
	X	23-dic					
	J	24-dic					
	V	25-dic					
	L	26-dic					
	M	27-dic					
	X	28-dic					
	J	29-dic					
	V	30-dic					
	L	31-dic					
	M	01-ene					
	X	02-ene					
	J	03-ene					
	V	04-ene					

Figure 3. Weekly Planning during the subject.

Once the agenda and the purpose of each practical activity is agreed, all the information was provided to students through the Moodle platform during the days before the completion of each session. Thus, upon the ending of each theory session, students had the possibility to find online supplemental materials, practical exercises (Fig.4), tests and theoretical tests of previous years in the virtual platform, generating a schedule of deliverables during different weeks.

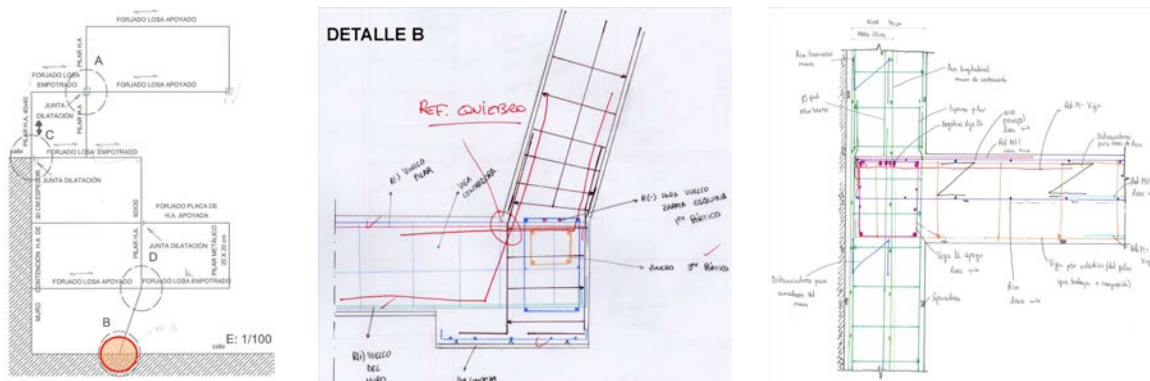


Figure 4. Example of details made by several students and uploaded to the Moodle platform.

As for the general assessment system, the evaluation (Fig.5) of the objectives' achievement will be carried out continuously throughout the course through written, oral or graphic tests, valuing their completion and making oral presentations to show their the acquisition of skills, their ability to synthesize and their capacity for logical and critical thinking.

- **EVALUACIÓN CONTINUA (65%)**
    - **PRÁCTICAS (20%)**
      - Puntúa siempre y cuando se asista al 80% mínimo.
    - **CUADERNO (10%)**
      - Relacionados con los distintos temas.
    - **EJERCICIOS (0%)**
      - Serán voluntarios.
  - **CONTROL (35%)**
    - Temas 1-7
    - Calificación control  $\geq 4,0$  para hacer media.
- **EXAMEN FINAL (35%)**
  - Temas 8-10 Y 1-3 (Maderas).
  - Calificación final  $\geq 4,0$  para hacer media.
- **RECUPERACIÓN CONTROL (35%)**
  - Temas 1-7
  - Calificación control  $\geq 4,0$  para hacer media.

No recuperable

Figure 5. Evaluation criteria and main percentages.

Tests will be conducted throughout the semester within school hours. To obtain the 50% of the final mark for continuous assessment, it is mandatory that the student has done and presented, in each of the relevant meetings, at least 90% of the programmed practices of the course (Fig.6). Students who do not present 90% of the mandatory practices in their respective school days are not assessed continuously, but can choose the final exam.

CONSTRUCCIÓN DE ESTRUCTURAS I (16011)													No hace media										
Calificaciones: 2013-14																							
TEST													CONTROL 1		PRACTICAS		CUADERNOS		FINAL ENERO		RECUP. CONTROL		CALIFICACIÓN
Dni	mi	NOTA	NOTA1	NOTA	NOTA2	NOTA1,5	NOTA0,5	NOTA	NOTA0,5	NOTA	NOTA0,5	NOTA	NOTA0,5	NOTA	NOTA0,5	TOTAL							
8.00	0.80			8.5	2.58	1.2	0.1	8.0	2.90	8.5	2.98			8.5	2.98	3.1							
3.50	0.35			1.5	0.53	0.78	0.1	6.0	2.10	0.8	0.28			0.8	0.28	3.6							
8.00	0.80			4.8	1.68	1.14	0.4	9.0	3.15	4.8	1.68			4.8	1.68	7.2							
4.50	0.45			2.4	0.84	1.14	0.4	6.0	2.10	8.0	2.80			8.0	2.80	6.9							
4.50	0.45			3.0	1.05	0.96	0.3	0.0	0.00	2.2	0.77			2.2	0.77	2.5							
7.00	0.70			7.5	2.63	0.78	0.1	5.0	1.75	7.5	2.63			7.5	2.63	6.0							
6.50	0.65			2.5	0.88	1.02	0.1	5.0	1.75	5.2	1.82			5.2	1.82	5.3							
7.50	0.75			2.0	0.70	0.78	0.1	1.0	0.35	5.0	1.75			5.0	1.75	3.7							
5.00	0.50			5.0	1.75	1.2	0.1	4.0	1.40	5.0	1.75			5.0	1.75	5.0							
8.50	0.85			5.7	2.00	1.02	0.3	8.0	2.80	5.7	2.00			5.7	2.00	7.0							
5.50	0.55			4.0	1.40	0.72	0.4																
5.50	0.55			4.0	1.40	0.72	0.3																
7.00	0.70			4.0	1.40	1.02	0	5.0	1.75	4.0	1.40			4.0	1.40	5.0							
8.50	0.85			2.3	0.81	1.02	0.4	3.0	1.05	3.0	1.05			3.0	1.05	4.0							
7.50	0.75			8.0	2.10	1.02	0.1	4.0	1.40	6.0	2.10			6.0	2.10	5.4							
2.50	0.25			0.0	0.00	0.9	0																
3.50	0.35			0.0	0.00	1.08	0.4																
4.00	0.40			1.5	0.53	0.9	0.2	2.5	0.88	4.5	1.58			4.5	1.58	4.0							
6.50	0.65			6.5	2.28	1.2	0.3	6.0	2.10	6.5	2.28			6.5	2.28	6.5							
7.00	0.70			7.5	2.63	0.96	0.3	6.0	2.10	7.5	2.63			7.5	2.63	6.7							
8.50	0.85			2.5	0.88	1.08	0.4	3.0	1.05	4.8	1.68			4.8	1.68	6.0							
4.50	0.45			4.0	1.40	0.96	0.1	8.0	2.80	6.5	2.28			6.5	2.28	6.6							
7.50	0.75			8.0	2.80	1.2	0.1	6.0	2.10	8.0	2.80			8.0	2.80	7.0							
5.00	0.50			5.8	2.38	1.2	0.3	2.5	0.88	6.8	2.38			6.8	2.38	6.0							
0.50	0.05			6.5	2.28	1.08	0.2	3.0	1.05	6.5	2.28			6.5	2.28	4.0							
6.00	0.60			4.0	1.40	1.02	0.3	3.0	1.05	7.7	2.70			7.7	2.70	4.0							
7.50	0.75			0.0	0.00	0.9	0.2																
6.00	0.60			0.0	0.00	0.78	0																
5.00	0.50			6.0	2.10	1.2	0.4	8.5	2.98	6.0	2.10			6.0	2.10	7.2							
4.00	0.40			2.8	0.96	1.08	0.2	3.0	1.05	1.0	0.35			1.0	0.35	3.1							
6.50	0.65			3.0	1.05	0.96	0.2																
4.50	0.45			0.0	0.00	0.96	0.2	0.5	0.18	6.3	2.21			6.3	2.21	4.0							
0.50	0.05			3.0	1.05	0.72	0.2	1.0	0.35	6.5	2.28			6.5	2.28	3.6							
7.00	0.70			3.5	1.23	1.08	0.3	3.0	1.05	1.0	0.35			1.0	0.35	3.5							
3.50	0.35			3.0	1.05	1.08	0.2	4.0	1.40	2.4	0.84			2.4	0.84	3.9							

Figure 6. Monitoring the progress of students, their deliveries and qualifications.

## 5 CONCLUSIONS

Setting weekly goals in practical exercises during the course enhances participatory presence of students to all classes and continuous work, ensuring the development and delivery of practical exercises on time and achieving quality objectives.

Corrections and public exhibitions of carried work encourages individual enforceability in students and enhances the sharing of knowledge and skills.

The teaching methodology experienced in the subject of Construction of Structures I is equally applicable to other subjects of the degree with different content, because of the knowledge or skills developed and since the proposed methods and results are directly linked to practical aspects of the profession, which is extensible to other degrees, all subjects and topics.

It has been found that the development of online contents allows a better learning and synthesize the diversity of knowledge acquired by the student in different blocks (theory and practice), embodying the basic principles of the subject.

In conclusion, the use of an online platform has enabled the acquisition of specific knowledge and construction criteria on an ongoing basis, but also it has been highly appreciated by the students through a direct and personalized learning with 24-hour monitoring.

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