

# InMotion

Innovative teaching and learning strategies in open modelling and simulation environment for student-centered engineering education

Report for the Working Packages 3.6, 4.6 & 6.6  
MOOCs for Long Life Learning (LLL)  
Evaluation of MOOCs for LLL  
Promotion of LLL training



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# ABSTRACT

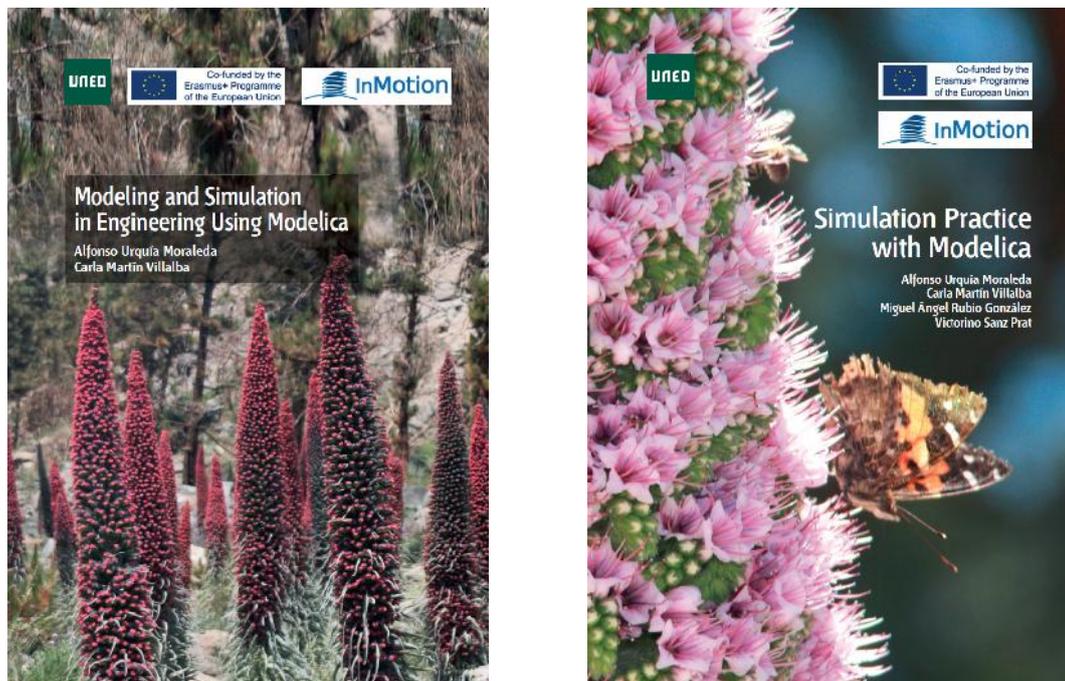
This document describes the objectives, structure, content and evaluation of a Massive Open Online Course (MOOC) entitled **Modeling and simulation in Engineering using Modelica** that has been developed within the InMotion project, and was offered by UNED Abierta between February 15 and April 30, 2019. The platform used by UNED Abierta is edX Studio.

## MOOC OBJECTIVES

Our intent in developing this MOOC is to provide, mainly through a series of videos, a gentle introduction to the design of model libraries applying the object-oriented modeling methodology, the development and use of model libraries in Modelica [1], and the use of two Modelica modeling environments: Dymola and OpenModelica.

The MOOC content consists of conceptually simple materials, selected from the two InMotion e-books on Modelica developed by UNED (see Figure 1). This content is presented in a way that makes it accessible to a broad audience.

The target audience is students interested in modeling and simulation, and with a background in both physics and numerical methods. The time of study required for students to complete the online course is approximately 25 hours.



**Figure 1.** Front covers of two free e-books [2,3] written within InMotion.

**Expected learning results.** As a result of taking this course, students should be able to:

- design model libraries applying the object-oriented modeling methodology;
- develop and use model libraries in Modelica; and
- use Modelica modeling environments for editing, debugging and translating Modelica models, experimenting with the models and analyzing the simulation results.

## MOOC STRUCTURE AND CONTENT

The work plan displayed in Table 1 is offered to the students. According to it, the course content has been structured into a preface and four lessons. An screenshot of the MOOC is shown in Figure 2.

The preface contains two videos:

- The first one explains how to access to the two course e-books [2,3].
- The second one, entitled "Modelica: a standardization effort", explains the aim and first steps in the development of the Modelica language.

Each lesson is composed of a series of videos, recommended readings, and an evaluation test.

- The videos are based on the most basic and easy-to-understand content of Lessons 1, 2, 3 and 9 of the e-book [2], and on the Assignment 10 of the e-book [3]. Videos are in mp4 format and hosted in YouTube.
- The recommended readings consist in some selected parts of the free e-books [2,3], where the video contents are repeated and extended.
- The evaluation tests are multiple-choice tests, intended to assess understanding of the concepts and practical skills. Concerning the latter, some questions contain the description of a system and students are asked to write by themselves the model equations, describe the model in Modelica, simulate the model, and answer, by selecting the correct response, a multiple-choice question concerning the obtained simulation result. The minimum passing score is 60% of correct answers.

Continuous-time modeling is addressed in the first three lessons of the MOOC, and hybrid modeling in the fourth lesson of the MOOC.

- In Lessons 1 to 3, students learn the fundamentals of the object-oriented modeling methodology, and how to apply this methodology for developing Modelica models and model libraries.
- Lesson 4 of the MOOC partially covers Lesson 9 of [2] and also covers the topic of model initialization in Modelica. The latter is explained in Lesson 7 of [2]. The material of Assignment 10 of [3], "The game of life" cellular automaton, is also included in the Lesson 4 of the MOOC. It is used to explain the Modelica features for discrete-event modeling, the use of the Modelica external function interface, and the implementation of graphical animations.

**Table 1.** Work plan proposed to the students in this MOOC.

## **PREFACE**

1. Watch the "[eBook access](#)" video to find out how to access the textbooks
2. Why Modelica? Watch the "[Modelica: a standardization effort](#)" video

## **LESSON 1 MODELING METHODOLOGY AND TOOLS**

3. Watch the following videos:
  - a. The "[Introduction to Lesson 1](#)" video
  - b. The "[Physical modeling paradigm](#)" video
  - c. The "[Object-oriented modeling](#)" video
  - d. The "[Modeling environments](#)" video
  - e. The "[Getting started with Modelica](#)" video
  - f. The "[Dymola tutorial](#)" video
  - g. The "[OpenModelica tutorial](#)" video
4. Read Lesson 1 of [2]
5. Answer evaluation Test 1 ([Microsoft Word](#), [pdf](#))

## **LESSON 2 CONTINUOUS-TIME ATOMIC MODELS**

6. Watch the following videos:
  - a. The "[Introduction to Lesson 2](#)" video
  - b. The "[Rectifier circuit](#)" video
  - c. The "[Translation in one dimension](#)" video
  - d. The "[Translation in two dimensions](#)" video
  - e. The "[Heat transfer in a pipe](#)" video
7. Read Lesson 2 of [2]
8. Answer evaluation Test 2 ([Microsoft Word](#), [pdf](#))

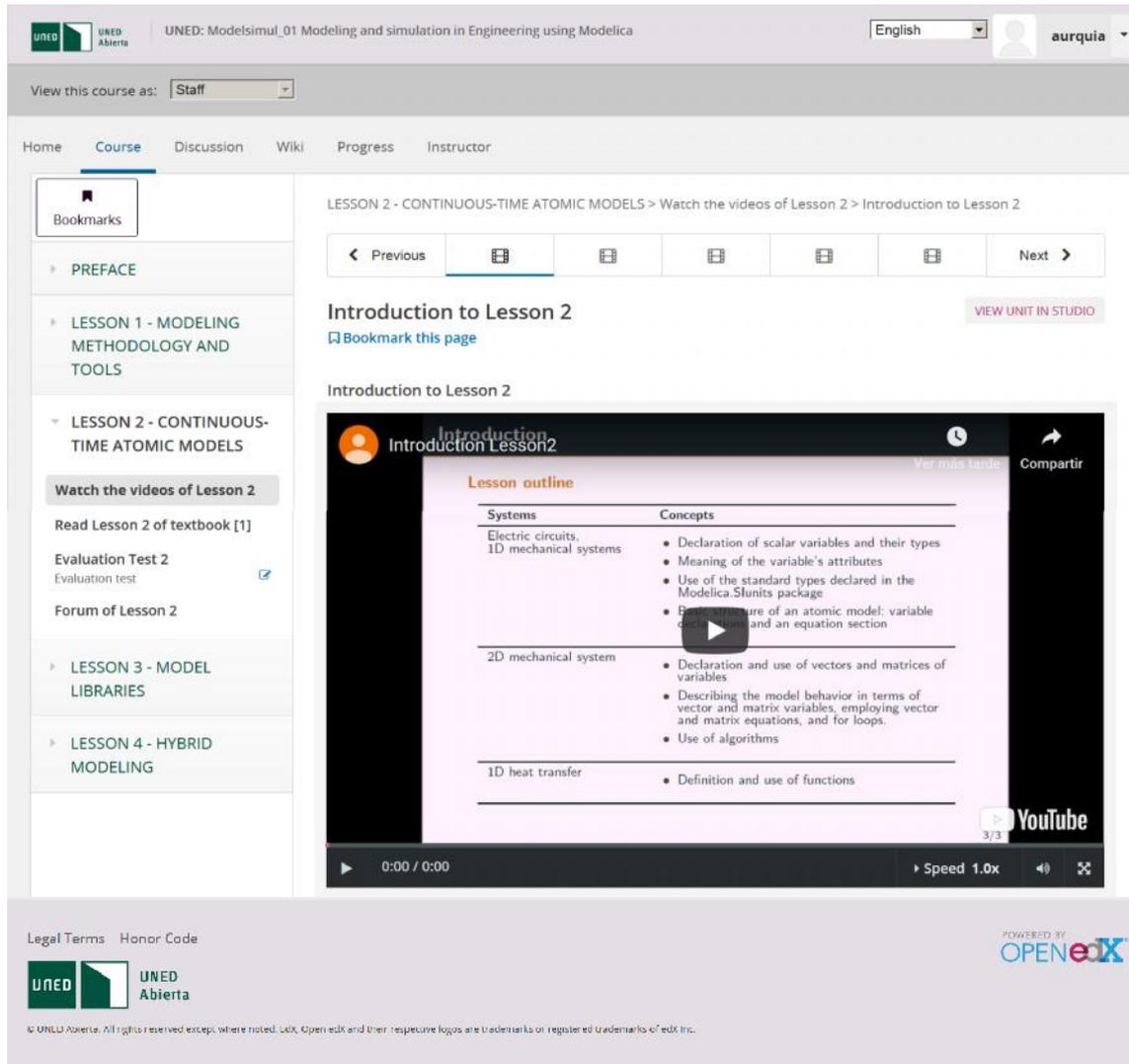
## **LESSON 3 MODEL LIBRARIES**

9. Watch the following videos:
  - a. The "[Introduction to Lesson 3](#)" video
  - b. The "[Electrical library](#)" video
  - c. The "[Vibrations of a bar](#)" video
  - d. The "[Heat conduction in a bar](#)" video
  - e. The "[Control of level and temperature in a tank](#)" video
  - f. The "[Dissipation of heat generated in a circuit](#)" video
10. Read Lesson 3 of [2]
11. Answer evaluation Test 3 ([Microsoft Word](#), [pdf](#))

## **LESSON 4 HYBRID MODELING**

12. Watch the following videos:
  - a. The "[Introduction to Lesson 4](#)" video
  - b. The "[Hybrid modeling](#)" video
  - c. The "[Model initialization](#)" video
  - d. The "[Cellular Automata - Game of Life](#)" video
13. Read Lesson 9 and Section 7.6 of [2], and Assignment 10 of [3]
14. Answer evaluation Test 4 ([Microsoft Word](#), [pdf](#))

**GIVE US YOUR FEEDBACK!** Answer the [MOOC evaluation questionnaire](#)



**Figure 2.** Screenshot of the MOOC.

**Communication channels.** A discussion forum is associated with each lesson. These forums are intended to facilitate discussions with instructors and among students, concerning the lesson topics.

A welcome letter was sent to the students at the starting date of the MOOC, and also placed in the MOOC for late-arriving students. In this letter, we explained our position concerning the use of the MOOC forums:

Some students perceive interactions in MOOCs as highly important. Others think otherwise. We neither encourage nor discourage the students to participate in online discussions. This is your personal decision. As we are not going to post regularly discussion topics to encourage communication, online discussions will need to be initiated by students. We will do our best in monitoring the discussions regularly and providing technical help, and in summarizing online discussions at the conclusion of each discussion.

# MOOC EVALUATION

The questionnaire that we have employed for the students to evaluate our MOOC is based on the Student Evaluation of Educational Quality (SEEQ). SEEQ is a standardized course-evaluation instrument, developed by [5], commonly used in higher education in the USA, as well as in other countries [6,7].

As the completion time of the full SEEQ is approximately 20 minutes, we have employed a reduced set of SEEQ questions. Our questionnaire is composed of 11 questions, divided into 5 sections: learning, organization, assignments, overall evaluation and comments/feedback. It is shown in Table 2.

**Table 2.** Evaluation questionnaire used in our MOOC.

<b>Instructions</b>							
For each of the following statements, select the response that most closely expresses your opinion							
<b>STATEMENTS</b>	<b>RESPONSES</b>						
<b>LEARNING</b>							
1. I have found the course intellectually challenging and stimulating	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
2. I have learned something which I consider valuable	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
3. My interest in the subject has increased as a consequence of this course	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
4. I have learned and understood the subject materials of this course	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
<b>ORGANIZATION</b>							
5. Instructor's explanations were clear	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
6. Course materials were well prepared and carefully explained	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
7. Proposed objectives agreed with those actually taught so I knew where the course was going	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
<b>ASSIGNMENTS</b>							
8. Required readings/texts were valuable	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
9. Further readings, tasks and auto-evaluation formularies contributed to appreciation and understanding of subject	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
<b>OVERALL</b>							
10. As overall rating, I would say the course is	NA	Very Poor	Poor	Average	Good	Very Good	
<b>COMMENTS/FEEDBACK</b>							
11. Please, provide any additional comments or feedback	Text (Max. 4000 characters)						

# RESULTS AND DISCUSSION

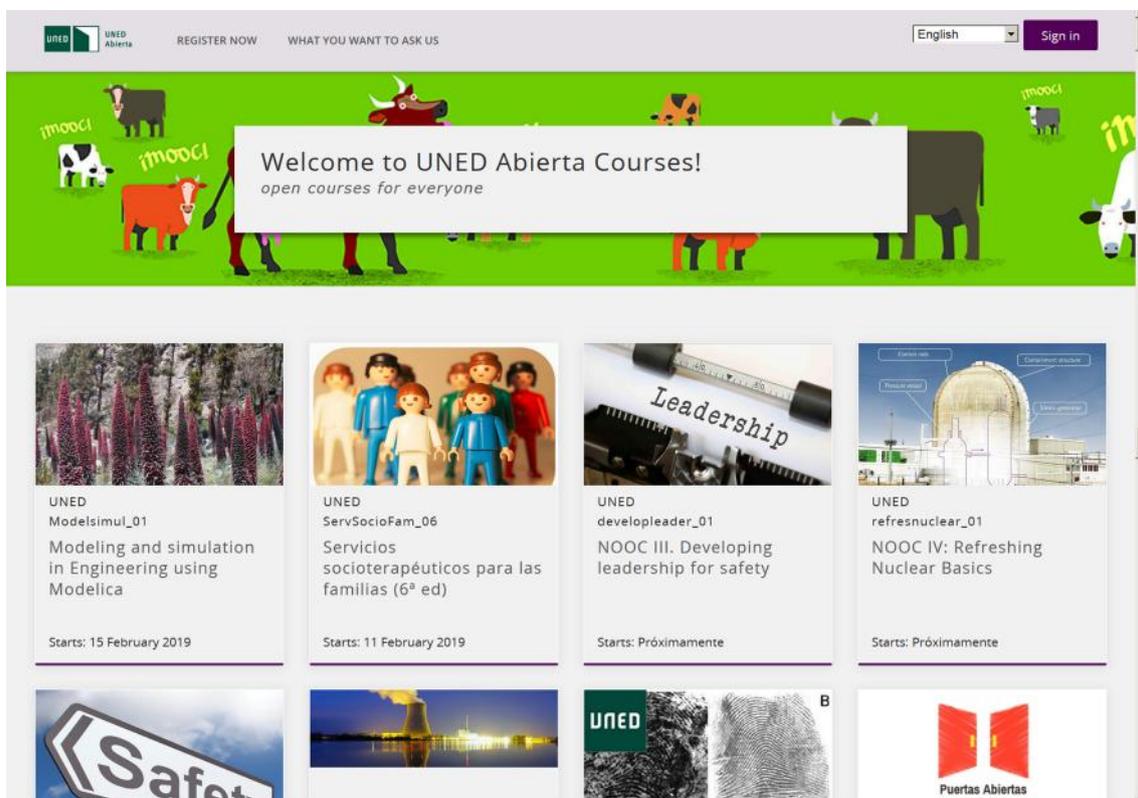
The MOOC was offered between February 15 and April 30, 2019. A screenshot of the UNED Abierta website is shown in Figure 3. The access to our MOOC is located in the first row, first column of the course table.

The evolution in the number of students enrolled in the MOOC is shown in Figure 4. The final number of enrolled students was 152.

The frequency histogram of the students' age (self-reported) is shown in Figure 5. It can be observed that approximately 40% of students are younger than 26 years old, 26% are between 26 and 40 years old, and 34% are older than 40 years old.

The percentage histogram of students' gender (self-reported) is shown in Figure 6. It can be observed that approximately one out of four students enrolled in the MOOC are women.

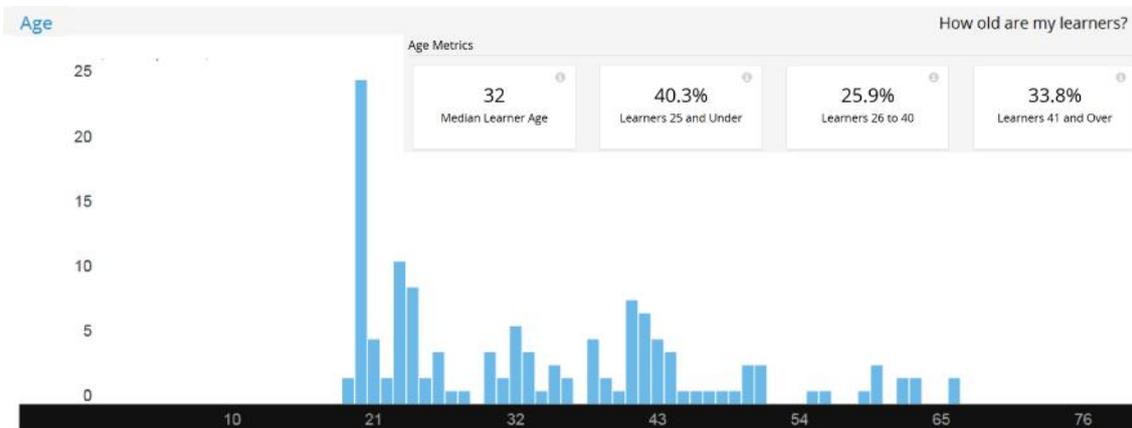
The students' geographic distribution (self-reported) is shown in Figure 7. Spain (47% of learners), Russia (25% of learners) and Malaysia (13% of learners) are the three top countries. Students from another 15 European, American and Asian countries have enrolled in the MOOC.



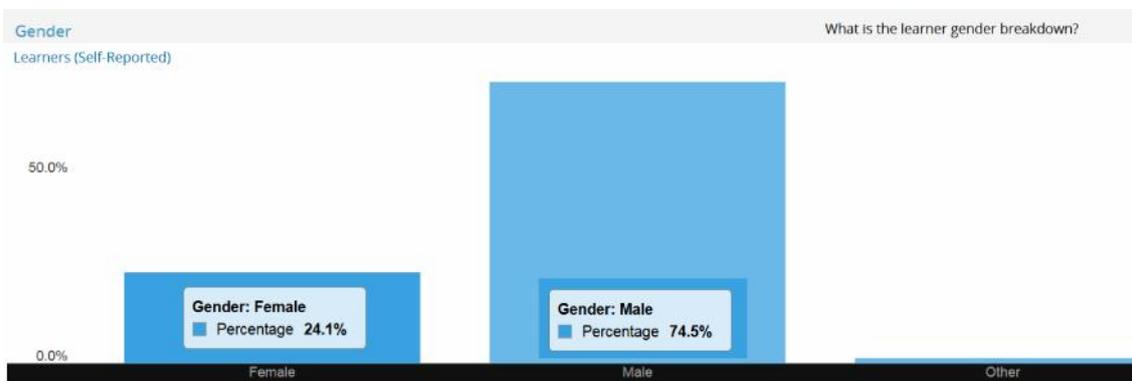
**Figure 3.** The MOOC was offered by UNED Abierta [4] for the first time in 2019.



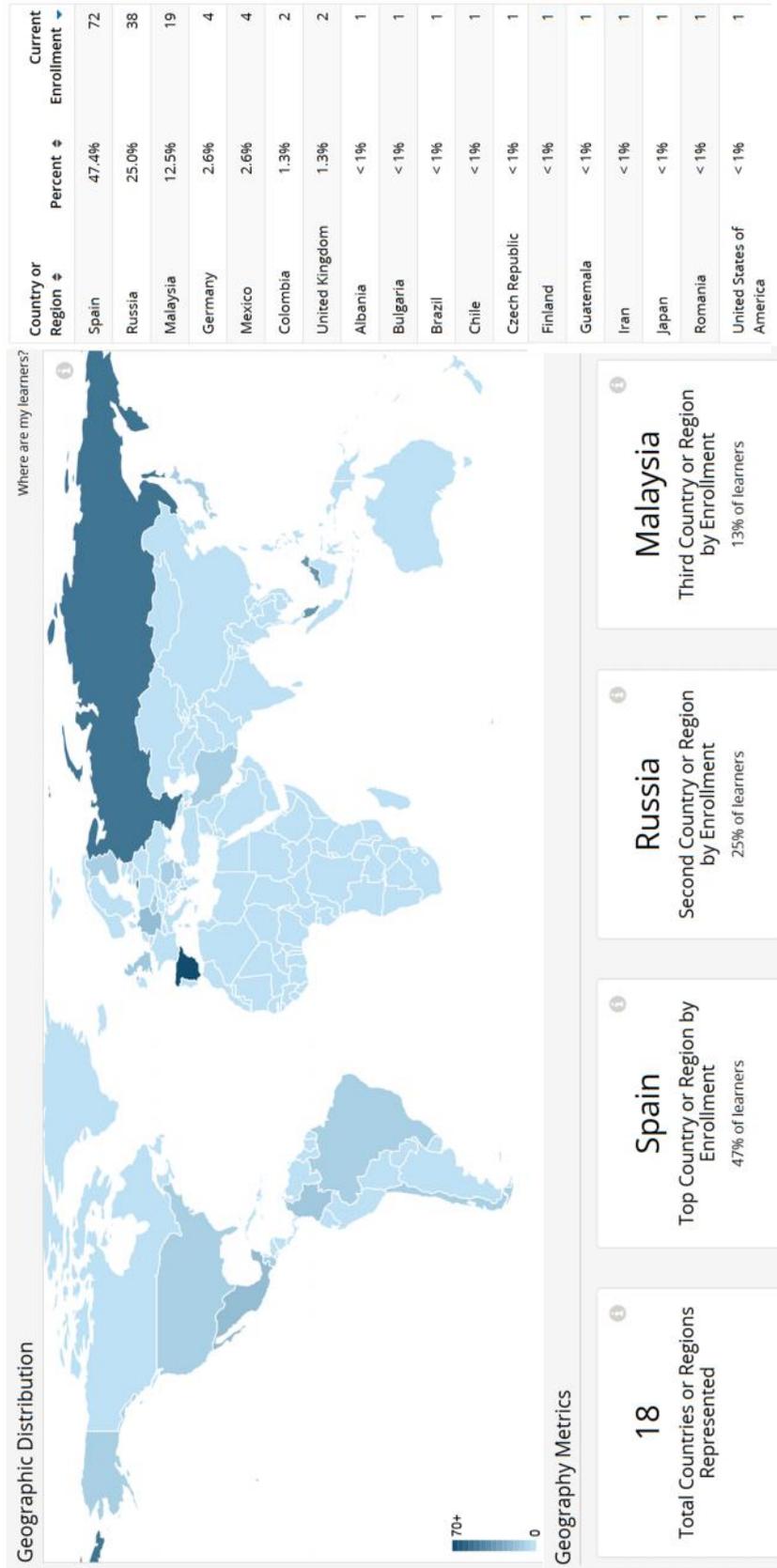
**Figure 4.** Evolution in the number of students enrolled in the MOOC.



**Figure 5.** Frequency histogram of students' age. The vertical axis represents the number of students and the horizontal axis represents their age.



**Figure 6.** Percentage histogram of students' gender.



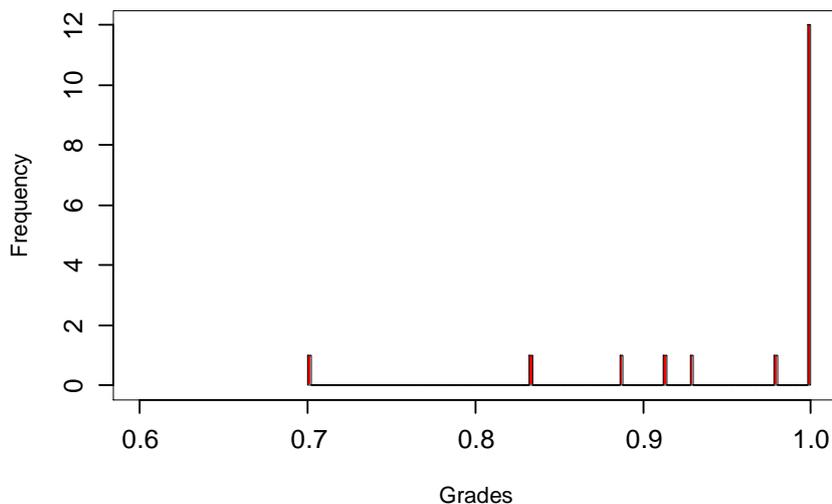
**Figure 7.** Students' geographic distribution.

Each lesson of the MOOC contained an evaluation test.

- 18 students have completed successfully the four tests.
- 4 students have answered only Test 1.

This implies that approximately 85% of the students have not attempted to answer any of the four evaluation tests provided in the MOOC.

The frequency histogram of the proportion of correct answers is shown in Figure 8. Only the 18 students that have successfully completed the tests are considered. It is worthwhile to note that 12 students have obtained 100% of correct answers.



**Figure 8.** Frequency histogram of the proportion of correct answers.

The MOOC students have not employed the discussion forums: the number of messages in the MOOC forums has been zero.

Only 8 students (i.e., approximately 5% of the MOOC students) answered the MOOC evaluation questionnaire (shown in Table 2). According to our experience at UNED, obtaining such a low number of responses in subject evaluation questionnaires is not uncommon in distance education.

The student responses are displayed in Table 3. The number of students that selected each answer is annotated in red color. The complete comments given by the students in response to Question 11 are provided, and related with the overall rating provided by the corresponding student.

**Table 3.** Student response to the evaluation questionnaire.

<b>Instructions</b>						
For each of the following statements, select the response that most closely expresses your opinion						
<b>STATEMENTS</b>	<b>RESPONSES</b>					
<b>LEARNING</b>						
1. I have found the course intellectually challenging and stimulating	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
				3	4	1
2. I have learned something which I consider valuable	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
				1	7	
3. My interest in the subject has increased as a consequence of this course	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
			3	1	4	
4. I have learned and understood the subject materials of this course	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
				6	2	
<b>ORGANIZATION</b>						
5. Instructor's explanations were clear	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
			3	1	4	
6. Course materials were well prepared and carefully explained	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
			3	2	3	
7. Proposed objectives agreed with those actually taught so I knew where the course was going	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
			1	4	3	
<b>ASSIGNMENTS</b>						
8. Required readings/texts were valuable	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
			1		6	1
9. Further readings, tasks and auto-evaluation formularies contributed to appreciation and understanding of subject	NA	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
			1	1	6	
<b>OVERALL</b>						
10. As overall rating, I would say the course is	NA	Very Poor	Poor	Average	Good	Very Good
			1	2	4	1
<b>COMMENTS/FEEDBACK</b>						
11. Please, provide any additional comments or feedback	<b>Overall rating</b>	<b>Comment</b>				
	Poor					
	Average	I would add the Russian language, it would contribute to the influx of young users from Russia to the site				
	Average	It seems to me that the course will be useful for people who want to learn something new for themselves. If you are fluent in English, you will not have problems with this course. However, the recorded video lessons are heavy because the author speaks with a Spanish accent, which sometimes made it difficult to understand some words. I liked the tasks in electronics tests, it was interesting to solve them and learn how some terms will sound in English.				
	Good	Thank you!				
	Good	It was hard to understand in English. It was interesting, but the lecturer's pronunciation leaves much to be desired.				
	Good	To provide more powerpoint for detail information.				
	Very good					

## CONCLUSIONS AND FUTURE WORK

The overall results for the first edition of this MOOC are satisfactory. It is important to note that, in this first edition, the course has reached students from multiple nationalities. Although the completion rate of the course is low, similar rates have been usually reported in the literature. On the other hand, students that finished the course obtained very good results in the evaluation tests. Also, the answers submitted by students in the feedback questionnaires provide very useful information to improve future editions of the course.

In particular, we will consider including Spanish, Russian and English subtitles in the videos; and provide additional slides with summarized contents to facilitate students to identify key concepts.

The MOOC will be offered again the next year, from February 15 to April 30, 2020.

## REFERENCES

- [1] Modelica Association. URL: <https://www.modelica.org>. Accessed in 2019.
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