

# A CALCULUS COURSE WITH INTERACTIVE SUPPORT ON MOODLE

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## Abstract

We are offering a course on Calculus. The contents of this course are adapted to the contents of a Calculus subject in any Engineering high degree or scientific Bachelor. But there is something that makes this course different from others. Not only do we offer a book with all the theory concepts of the subject, but also a digital version of the book with interactive exercises and laboratories. We have developed a course on Moodle with all the theory as well as with a great variety of 2D and 3D pictures and graphics. There are also many exercises which are offered in a random way in order to evaluate and autoevaluate the course. The platform Moodle allows, on the one hand, that the professors make a personal course for their subject adapting the contents in which they are interested (therefore we offer a wide range of difficulty, including from easy practice exercises and concepts taught in technical degrees until the pure mathematical concepts taught in a Mathematics M.Sc. degree. On the other hand, the student can learn 24-hours a day in the specific topic or field he wants and can learn the theory concepts as well as practice with the different tests and exercises offered. The laboratories that you can find in the virtual course want to help students to understand the very conceptual contents and therefore illustrate examples of the application of theorems or properties. Both the students and the teachers can work a lot on the course and so get better and better results. The material is high motivating and therefore higher results are easy obtained. A virtual contact between teachers and students (or even among students) is always available through forums or chats. All this possibilities are easily negotiated by Moodle with the interactive support offered by the mathematical software Wiris.

Keywords: Interactive, Moodle, Calculus.

## 1. NEW LEARNING AND TEACHING STRATEGIES

The introduction of distance and Electronic Learning Technology (e-learning) in teaching institutions is often complex and educators do not always accept the Information and Communication Technologies (ICT) as expected. The Web offers exceptional opportunities for worldwide access to learning resources; specifically the Web and associated technologies have provided a new environment with new rules and tools to deliver instruction and create novel approaches to learning. However, since the Web is a new medium for course delivery and learning, and it is not well identified which mediating and moderating factors in the online environment contribute more to its acceptance and use. It is a new framework for both educators and learners.

There is a great amount of ideas, items and experiences to present and discuss about the mathematical activity in the 21st century classroom. We are concerned about how the new technologies help the design of the mathematical activities and what kind of new topics can be discussed because of the existence of these new technologies. To explore how might new and ancient technologies live together and strengthen each other is not a simple aim. We are convinced that it is necessary to use these new possibilities, and after that, an analysis of the results achieved must be performed with rigor. Without this, the experience in teaching-learning process is not completed. It is essential to know how to put in practice new activities and it is also compulsory to know how to improve them from the evaluation of their implementations.

Moodle is a course management system, a software package designed to help educators create quality online courses and administer learner outcomes. The design and development of Moodle are based upon a particular philosophy of learning, a way of thinking that is referred to in shorthand as

'social constructionist pedagogy'. Atenea is based on Moodle, an open source learning management system, which offers a wide variety of tools.

In this project we offer a solution based on the Moodle platform which allows both teachers and students to take advantage of all the possibilities available through this software. Moodle is open source software thought to be the key in the future learning strategies and that is the reason why most of European Universities have already included Moodle on their virtual campus. This software offers a great range of possibilities and can be easily adapted to a particular subject. We have developed a course on Calculus based on this software and therefore a long theory background on this subject has been included as a pillar of this course.

As both e-learning and classical learning are found essential by most of the students, a paper book [1] has also been written at the same time. All the theory contents as well as the examples and exercises can be found in the book. Furthermore, the same contents have been included in a Moodle course. What is then new? In the Moodle course, there have also been developed new activities such as multiple choice tests or questionnaires, interactive laboratories and interactive graphics. That is basically what makes this course more powerful than others.

## 1.1 Contents

Another good point of having a course in this software is that it becomes extremely easy to make it personal and flexible. This course is thought to be used by all the different ranges in which a Calculus course is taught, from the easiest courses found in some short technical degrees and until the Calculus taught in the Mathematics Bachelor degree. Because of this, the course includes all the following contents with an absolute depth (a depth that will be able to be chosen by each teacher) in the topics.

1. Introduction to number sets. Real and Complex numbers.
2. Basic topology in metric spaces.
3. Numerical series and sequences
4. Real functions of real variable.
5. Multivariable functions.
6. Primitives.
7. The Riemann integral.
8. Multiple Riemann integral.
9. Functional series and sequences.

The course is then divided in nine different chapters. Each of these chapters includes the theory behind the topic, many different examples showing how to use this theory, some exercises to let the student work and learn, a questionnaire in order to make the student be aware of his or her improvements and knowledge, and some interactive contents dealing with the theory and examples, including laboratories or graphics.

## 2. A CHALLENGING MATERIAL FOR STUDENTS

Students of this course will have the chance of learning straight from the paper book with all the docent material and contents of a Calculus course through the theoretical development and proofs of all the results, examples and exercises of the book, but at the same time, they will have the opportunity of experiencing the advantages of learning Calculus from a bank of interactive activities.

On the one hand, there are a wide variety of virtual laboratories that will help the student learn and understand better the concepts and results through an interactive way. An example of these laboratories is shown in the figure below, which helps the students to understand how the Riemann Integral is constructed, defined and its geometrical interpretation.

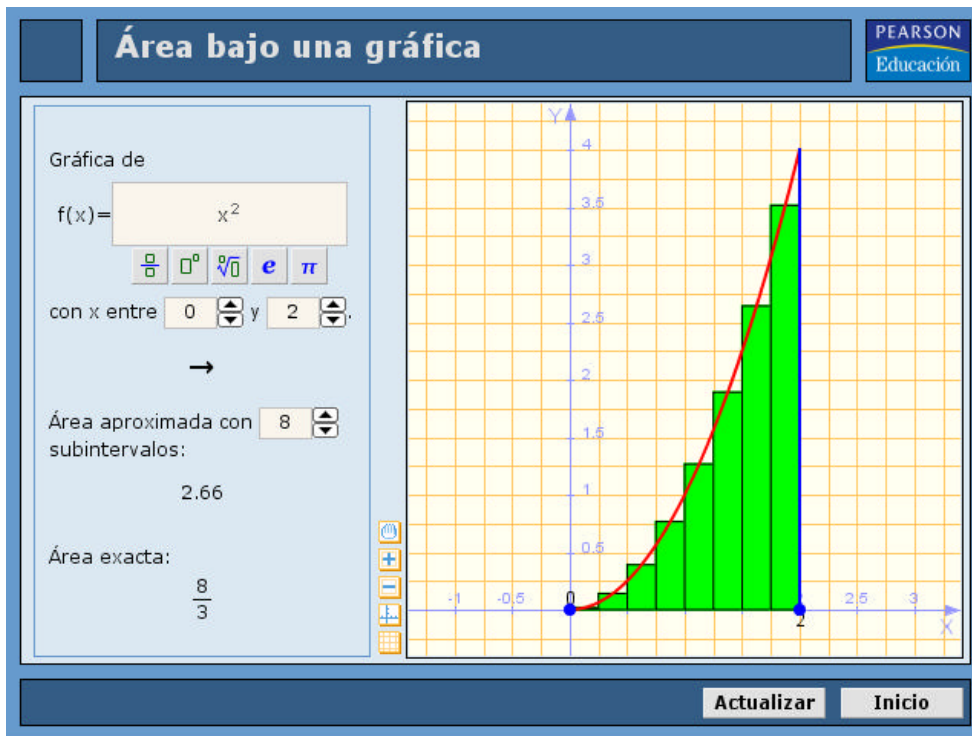


Fig.1. Laboratory

The students will also find a bank of exercises which are thought to be self training. These exercises are developed with the mathematical software Wiris and so are programmed in a way that the students can interact with them. The students will be able to change parameters, change the visualization of the graphic (if there is one) and even change the type of exercise. A good example of these virtual exercises is shown in the figure 2 in which the student is asked to guess whether the functional sequence converges or not.

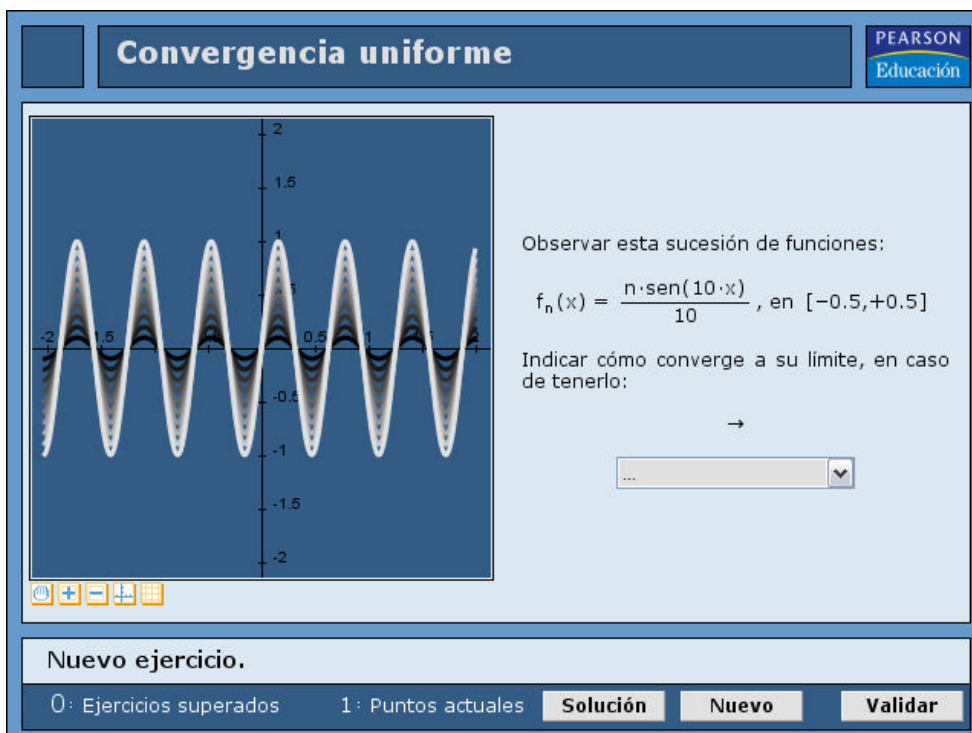


Fig.2. Virtual exercise

By clicking on the Solution button the student will be allowed to see the correct answer; if he or she clicks on the New button the student will be given a new exercise on the same topic and by clicking on the Validate button the student will be able to check whether he or she has given the correct answer. It is always shown how many exercises the student has already done, and how many of them correctly. Through the icons under the graphic and also clicking on the picture it is also permitted to see the figure from a different point of view, zoom in and zoom out...

Another motivating task that the students will find is a large collection of questionnaires, distributed in different banks according to the main topic of each chapter. This tool, the quizzes module, allows creating quizzes with different question types, adapted to the specific objectives to be achieved at any step in the teaching-learning process. A powerful tool for monitoring and diagnosing a student's understanding of knowledge, Moodle quizzes contributes to the development of new strategies not practical with paper-based testing. To explore how to apply these new strategies and be able to develop a substantial bank of quiz questions, we are carrying out subsidized projects by the Institute of Education Sciences (ICE) of the UPC. There is a questionnaire of 10 different questions taken from a large bank at the end of each chapter. The student should take the test and, if satisfactory, he or she will realize that they are able to go on with the next chapter. The instructor is always allowed to check the grades (there can be different grades for the same test, if it has been taken by the same student more than once) and decide whether the student is permitted to start the next section or not.

Every quiz has 10 questions and an example of these questions can be seen in the figure below. It can also be seen how easy and user friendly it is to surf through this module for the students taking the test.

**7** Si  $x, y \in \mathbb{R}^n$  y  $d(x, y) = 3$ , entonces podemos afirmar que,

Puntos: -/1

Seleccione una respuesta.

- A. Ninguna opción es cierta
- B.  $y \in B(x, 4)$
- C.  $\exists z \in \mathbb{R}^n$  tal que  $d(x, z) = 1$  y  $d(y, z) = 1$
- D.  $x - y \in B(0, 3)$
- E.  $\|x - y\| = \sqrt{3}$

Enviar

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**8** Considerar el espacio euclídeo  $(\mathbb{R}, d)$  y para  $x, y, z \in \mathbb{R}$  la desigualdad

$$|x + y| \leq |x + z| + |z - y|$$

Puntos: -/1

Seleccione una respuesta.

- A. Cualquier valor de  $x, y, z \in \mathbb{R}$  la verifica
- B. Sólo se verifica si  $z = x = y$
- C. No existe ningún valor de  $x, y, z \in \mathbb{R}$  que la verifique
- D. Sólo se verifica si  $|z| \leq |y|$  o si  $|z| \leq |x|$

Enviar

Fig. 3. Examples of quiz questions

### 3. A NEW TEACHING IMPROVEMENT POSSIBILITY FOR PROFESSORS AND INSTRUCTORS

All the teachers that choose to use this course automatically have the chance of implementing all the contents instantly in their Moodle course. If Moodle is already the virtual platform and software used by the University as a whole it is extremely easy to take advantage of the course: upload a backup of the main course, show and hide the part of the total material required and add the particular material that you, as a teacher, have for the course. If not, you can easily create a Moodle course, as the software is open source and free and make it personal and adapted to your own subject or you can just use the course already available through the website:

[www.pearsoneducacion.com/calculoenmoodle/](http://www.pearsoneducacion.com/calculoenmoodle/)

So the best think of having the course on Moodle is that the different instructors can make the course personal and perfectly adapted to what they need. They can add new question banks, attach pdf files, hide extra information or even add what they find is lacking. The last result is a whole course on Calculus that perfectly suits the contents and materials for the particular where it is taught.

Another good opportunity that the Moodle courses offer is the chance of an easier management. All the course grades and notifications can be managed through the platform, and so there is a continuous and absolute connexion between the instructor and the student. It can be seen in the figure below the final table of grades summary for each student. That is what the instructor sees, because the students can only check their own grades.

Cálculo										
Nombre / Apellido ↑	Números reales y complejos	Topología básica en series numéricas	Sucesiones de series reales de variables	Funciones de varias variables	Funciones de varias variables primitivas	Cálculo de primitivas	La integral de Riemann	Integrales múltiples y Series de	Sucesiones y Series de	Total del curso
😊 u6tgw8a u6tgw8a	-	-	-	-	-	-	-	-	-	-
😊 u6u5x5a u6u5x5a	-	-	-	-	-	-	-	-	-	-
😊 u6u8uj8 u6u8uj8	-	-	-	-	-	-	-	-	-	-
😊 u6upymm u6upymm	-	-	-	-	-	-	-	-	-	-
😊 u6v7i0d u6v7i0d	-	-	-	-	-	-	-	-	-	-
😊 u6ve4t7 u6ve4t7	-	-	-	-	-	-	-	-	-	-
😊 u6vf9n3 u6vf9n3	-	-	-	-	-	-	-	-	-	-
😊 u6vignl u6vignl	-	-	-	-	-	-	-	-	-	-
😊 u6x7li8 u6x7li8	-	-	-	-	-	-	-	-	-	-
😊 u6x8tri u6x8tri	-	-	-	-	-	-	-	-	-	-
😊 u6xmle5 u6xmle5	-	-	-	-	-	-	-	-	-	-
😊 u6xomkh u6xomkh	-	-	-	-	-	-	-	-	-	-
😊 u6xra44 u6xra44	-	-	-	-	-	-	-	-	-	-
😊 u6y216x u6y216x	-	-	-	-	-	-	-	-	-	-
😊 u6yqjwy u6yqjwy	-	-	-	-	-	-	-	-	-	-

Fig. 4. Table of grades

#### 3.1 Evaluation further possibilities

The questionnaires that we have already previously explained can also be done in order to evaluate the course. So they can be managed by an instructor and therefore be part of the final grade of the subject. To us it is not only the question whether ICT can be used to support learning, testing and assessing mathematical skills, but how this should take place. Not only grades and scores are important, but also the way how mathematical concepts are learned and tested diagnostically. We specifically aim to find out more about learning, testing and assessing.

For instructors, it is also very important to explore how to apply effective question-design strategies to supervise students' progress at different levels of the learning process, articulated in specified learning outcomes and skills: knowledge, comprehension, application, analysis, problem solving, then determine where students are having problems in their thinking.

We believe that the examination is very important and it is meaningless to do anything in terms of new pedagogical methods if you don't do anything about the examination at the same time. It is the examination that decides what and how people learn. So it is essential to be very careful with the assessment tasks, and we need to learn about our own assessment processes with our students in the Moodle framework. It is important to be able, after the examination process (before of it, sometimes is not easy to imagine the reaction of our pupils) answering the following query:

- i) Why is it an interesting question?
- ii) What skill or behavior is assessed here?
- iii) What answers do we expect?
- iv) What could be obstacles in answering this question?

The effort of developing tests is considerable. Because of the complexity of the total system, with several application interfaces involved, and the inherent complexity of mathematics, developing a question template can take up some time. But the last conclusion about this kind of testing students can only be optimistic: let's think and invest our time on developing quizzes and such questionnaires because the students find them specially helpful and useful.

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