

## ENGAGEMENT OF CIVIL ENGINEER STUDENTS IN THE FIRST ACADEMIC YEAR

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**Abstract.** Stronger student engagement or improved student engagement are common instructional objectives expressed by Higher Educational Institutions. They aim, in particular, at reducing the early dropouts of Science, technology, engineering, and mathematics (STEM) studies and to involve students in their own learning process.

This paper presents training resources and materials recently incorporated to the Calculus course of the first year of the Civil Engineering Bachelor at the Escola Tècnica Superior d'Enginyers de Camins Canals i Ports de Barcelona, in order to motivate and encourage students towards independent learning in mathematical topics.

One of these tools is a series of specific thematic math videos. They have different aims and scopes. On the one hand, they connect basic concepts of the Calculus course with relevant topics of Civil Engineering. On the other hand, they propose and state contextualized problems (pertaining to Civil Engineering) which are solved stepwise using Calculus tools and procedures. Moreover, there are different kinds of videos, namely: motivational, audiovisual workshops and audiovisual laboratories.

Producing and editing workshop videos required the cooperation of professors and also last year students in Civil Engineering. Being the speakers actual students, these videos convey to the target audience (first year students) a sensation of proximity and a potential easiness. Much more than if they were presented by a lecturer.

Initially, all of these videos were only accessible through the Civil Engineering School web portal, CaminsOpenCourseWare. Currently, the three collections of videos are already displayed on the YouTube channel, which provides more flexibility for access and allows controlling displays. They are also integrated into the web platform of the Calculus course, which allows students being immediately updated.

## 1 INTRODUCTION

Since the 1970s and 1980s, studies have been proposed as a major research project in the United States and British to analyze what characterizes the best universities, from the point of view of the experience and learning of their students. After the large research compilations carried out by Pascarella and Terenzini [10,11], Astin [1] and Kuh et al. [6,7] it was concluded that promoting high levels of student engagement is the most decisive factor from the point of view of student learning. [9]

In recent years the concept of student engagement has been becoming increasingly complex, while high-reliability measurement instruments such as the NSSE (National Survey of Student Engagement) in the North American field or the CEQ (Course Experience Questionnaire) in the British and Australian field appear. All these developments have made student engagement one of the priority attention points within universities and a methodological key to higher education research.

Student engagement has been described as the isolated variable that best predicts student success. Practically all of the policies and practices that research in recent decades has associated with high levels of student learning correlate positively with student involvement.

In the present paper we introduce the last resources and materials that we have incorporated in the Calculus course taught during the first year in the Civil Engineering degree at the Escola Tècnica Superior d'Enginyers de Camins Canals i Ports de Barcelona at the UPC BarcelonaTech. The lecturers of the Calculus course have always expressed our interest in providing a good learning of basic mathematics. We are interested in improving the quality of teaching and consequently we catch up on the latest teaching and learning improvements. One of our references is the International Conference Online Educa Berlin [8].

## 2 OPEN EDUCATIONAL RESOURCES FOR CALCULUS

Since 2003, we have been working on the development of mathematical content and implementing different educational tools in order to improve the teaching and learning of mathematics (especially Calculus) and the motivation of their students in the first year of the degree.

During this time, many resources and materials have been created and gradually incorporated into the Calculus course [4]. Among the varied resources that have been implemented since 2003 (a book [3] with the basic and fundamental needs to understand Calculus contents illustrated with a lot of descriptions, examples and both 2D and 3D plots; an interactive support based on Moodle and WIRIS technologies in order students can practice by themselves and even perform continuous assessment tests, online tutoring...), in this paper we present the latest upgrades, specific thematic math videos that, on the one hand, pretend to connect a basic issue of the Calculus course with a relevant topic of the Civil Engineering, and, on the other hand, suggest a contextualized problem (related to a Civil Engineering situation) which is solved step by step using Calculus concepts and procedures.

### 3 MOTIVATIONAL VIDEOS, AUDIOVISUAL WORKSHOPS AND LABORATORIES

In order to motivate the students of Civil Engineering to the Calculus study during the first year of this degree, and with the aim they really discover its utility and relevance in their future studies as the applications that this basic knowledge have in their future jobs, we edited some motivational videos for each topic of the Calculus course. Explanations of each of these videos are in charge of professors of the school, as well as distinguished PhD students of Civil Engineering degree, who explain their scope of work or studies and relate them with one of the different topics of the subject. As mentioned above, the goal is to establish a link between what is learned in Calculus lectures and its application in the Civil Engineering real world.

With them, we also aim to set the students closer to the topics that we suppose they have more interested in and, in fact, encourage them to initiates Civil Engineering studies. This allows really bring students the topics that from the academically point of view could be initially seeing very distant.

The fact that the application of the concepts studied in the Calculus first course displayed in those videos are given by a professional of the university school where students are studying and who are working in different fields of the degree, reaches a triple goal: closeness, motivation as well as to confirm the clear relationship and collaboration between different areas of knowledge (in this case, fundamental mathematics and the Civil Engineering field). A fact that not always is as evident as it has to be.

#### 3.1 Motivational videos

The motivational videos associated to each one of the topics of the Calculus course are [2]:

- Unit 1. Metric Spaces. Topology: *Basic Topology to create nets.*
- Unit 2. Numerical sequences and series: *Numerical Sequences and computational mechanics.*
- Unit 3. Differential calculus of real functions of a real variable: *Using generalized functions in beam theory.*
- Unit 4. Differential calculus of functions of several variables: *Differential calculus of functions of several variables in the optimal design of a public transport network.*
- Units 5-6. Riemann integral: *Riemann Integral. Application to hydraulic engineering field.*
- Unit 7. Function sequences and series. Fourier series: *Function series and metamaterials.*
- Unit 8. Ordinary differential equations: *The convergence - confinement method in ground -support interaction.*
- Unit 8. Ordinary differential equations: *Eigenvalue Problems and Applications to Structural Dynamics.*

Positive results achieved with this type of videos encouraged Calculus staff to subsequently create a new type of videos, but which have something more added.

### 3.2 Audiovisual Workshops

We thought in the realization of a new kind of videos which includes a new added factor based on workshops. We call them audiovisual workshops.

To achieve this idea, fundamental topics of Calculus have been collected. In this sense, selected topics are not the most complicated ones but the ones that students have to dominate and not always they succeed in. Such audiovisual workshops have not to be a substitute of what is done in regular lessons. Not everything is covered in these videos, but the most important information and an overview of the presented topic is developed. The goal, as it is said, is to complement and help students to set up the groundwork of the most fundamental aspects that are a key for any Calculus development.

All of these audiovisual workshops have a specific structure. They are divided in three interrelated parts, which are detailed above:

- Part I. *Tools*: where a brief theoretical and transversal lecture of the different Calculus tools will be needed to resolve the problem. The aim of this first part of the videos are to emphasize the understanding of the subject as a "whole" and not as a sum of different topics.
- Part II. *Resolution of a problem*. In this part, it is developed, step by step, a difficult mathematical problem applied into engineering. The intention of this part is students to improve in the development of the problem in conjunction with the interactive lecture. The difficulty of the problem lies in the correct comprehension of it. It is not just looking for the assessment of Calculus knowledge but for the sufficient abstraction of the student to correctly interpret what it is set out.
- Part III. *Approach of a new problem*. Finally, it is set out a new problem, which is similar to the developed before in order students feel able to work on it and really try to solve it by themselves. The fact that the proposed problem is similar to the developed one, allows students to consolidate knowledge and methods of resolution.

For each topic, theory and problems (both resolution and approach) parts are set in two separated videos. This fact allows students watching the desired ones separately, or one after the other one (in the order they need).

The fact that the problems suggested in these audiovisual workshops are contextualized in the world of engineering, returns to the idea of motivation and ratify the evidence and the importance of the presence of mathematics in engineering, in this case Civil Engineering.

The edition of such workshop videos has enjoyed with the cooperation of students who are finishing the Civil Engineering studies degree. The fact that the presenter of each video is truly a student conveys to students of the first year of the degree a much greater closeness and security in themselves than if they were displayed by a lecturer.

At this moment, the edited and uploaded audiovisual workshops are the following ones:

- Conics and Quadrics (1). Theory.
- Conics and Quadrics (2). Problem.
- Differential equations (1). Theory.
- Differential equations (2). Problem.
- Function approximations (1). Theory.
- Function approximations (2). Problem.
- Riemann integral (1). Theory.

- Riemann integral (2). Problem.
- Trigonometry (1). Theory.
- Trigonometry (2). Problem.

With the release of these videos, both motivational and audiovisual workshops, has always sought a direct and as comfortable as possible, interaction with the viewers (students) across the screen. This goal is achieved, on the one hand, through a neighboring language and no more than 15-20 minutes length per video. It is important to ensure that students who view the videos maintain their concentration throughout the duration of the lesson. During their exposure and development, students will have to feel comfortable in a quiet and relaxed atmosphere in order they can integrate well what is presented and worked. And on the other hand, the objective is achieved with the incorporation of different tools that technology provides.

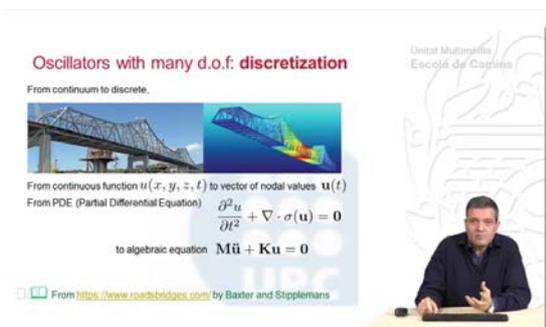


Figure 1: Motivational video

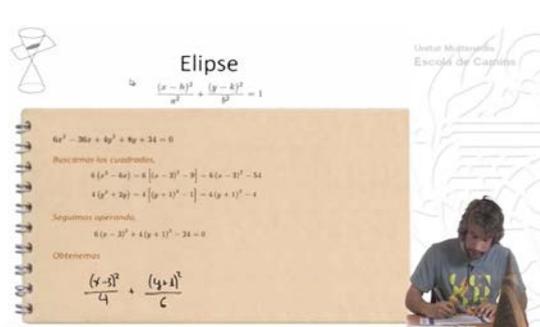


Figure 2: Audiovisual Workshop

The presenters of the motivational videos used a virtual presentation on which it is possible to do explanations, annotations, highlighting specific items... For the release of this second set of videos, for audiovisual workshops, the technology used is considerably expanded.

On the one hand, it is used a virtual pen. This smart pen allows displaying on the support presentation what one is writing on a sheet in real time. It allows viewers follow and reproducing developments and explanations at the time presenters are written on the presentation. This keeps the timing among the viewer students, leading to a positive effect on them. On the other hand, this innovative tool gives added value to the presentation making it more interesting and rich.

Other technological tools used are interactive applications, such as applets. These resources engage viewer students. The given visual information combined with the explanation in real time multiplies the options for a proper understanding of the topic which is presented.

Initially, all of these videos were only accessible through the Civil Engineering Web School portal CaminsOpenCourseWare [2], but now this collections of videos were displayed on the YouTube channel, which provide more flexibility to students to access them and a real control of their displays. And, afterwards they have been integrating into the web platform of the Calculus course, Atenea in Moodle platform, which allows students be immediately up-to-date among them.

### 3.3 Audiovisual Laboratories

The last type of videos we have, are the Audiovisual Laboratories. In this videos we illustrate with a lot of descriptions, examples and 2D and 3D plots, exercises using WIRIS technologies. The students can practice by themselves with continuous assessment.

At this moment, the edited and uploaded audiovisual laboratories videos are the following ones:

- Basic Topology
- Calculation of Primitives of a function
- Functions of several variables
- Function sequences and series
- Multiple integral
- Real functions of a real variable
- Riemann integral
- Sequences and numerical series



Figure 3: Audiovisual Laboratories

## 4 RESULTS

We believe the facts that a) students can access these materials through different web portals, b) students can display those videos at any time, c) videos can be interrelated at any time, and d) videos can be stopped and replayed from any specific moment the desired times and whenever students want, enhancing the Calculus learning. Thus, if these three collections of videos are properly used, can be a very successful tool for the study and daily motivation of the Calculus course in the first year of the Civil Engineering Degree.

### 4.1 Motivational videos results

All the students (100%) who answered the motivational videos' poll affirm both they know this collection of videos and they watched some of them. 50% of these students assure that they have seen three or four different videos, and 36%, five, six or seven (there are 7 videos) of them. All of the students assure that the videos they have seen provide them some help in their studies in some way (33% a little bit and the remaining, 67%, a lot of) [5]. According their responses, these videos provide them specifically:

- more interest in the Calculus topics studied in the course,
- real Calculus applications in Civil Engineering as well as in real life,
- a new vision of mathematics,

- more motivation and lively feelings in Calculus lessons
- a complement for the lessons explanations:
  - a) better understanding of what is working in attending lessons
  - b) a general idea of the concepts taught in lessons

Regarding from where students access to these videos, 68% affirm they saw them through the Calculus web platform, 27% from the OpenCourseWare and only 5% directly from YouTube [5]. This reaffirms that embed these videos in the Calculus web platform is the best and more reliable way students can easily access to them.

According to the obtained results, 97% of the students think motivational videos are both edited in a friendly and present the different topics in an understandable way.

Finally, we asked students their general opinion about the videos, and according their responses, we can conclude these videos are well accepted for them. (37% very good, 37% good, 23% regular and 3% bad) [5].

Some of the students who answered the opinion poll highlight some aspects that we think are important to be considered:

- Students who don't visualize the 7 videos of the collection, highlight that they haven't do it because of lack of time.
- They like lecturers remember that videos are hold on the web more often.
- They would like there will be more videos like them.

The number of times that these videos have been viewed can give us an idea about which of them was more useful for students.

## 4.2 Audiovisual workshops results

In this case 10% of the students who answered the poll who didn't realize about the audiovisual videos. From 90% who affirms knowing them, 10% assures they saw all the videos (there are 10 audiovisual workshops), 6% most of them and 57% only some of them.

90% of the students who saw these videos assure they help them to revise, learn and consolidate some concepts, procedures and ideas taught in attending Calculus lessons, and the same percentage think videos are edited in a friendly and understandable way. On the other hand, through the opinion poll we notice that the more comfortable way for students to access to the videos is through the Calculus web platform, like happens for motivational videos.

The general opinion of these students about this collection of audiovisual workshops is also so good, (37% very good, 33% good, 26% regular and 4% bad) [5].

Regarding the plays of the videos of this collection it is clear that Conic and Quadrics audiovisual workshops are the most demanding for our students.

An assumption towards this evidence is that Calculus students need to manage Conics and Quadric expressions and representations, but on the one hand, it is not a specific topic of the course and on the other hand, students haven't studied them before in Secondary school. This fact makes clear that audiovisual workshops are a really useful resource for Calculus students in order to get confidence in some topics that are not always can be emphasize in lectures.

### 4.3 Audiovisual laboratories results

This videos are recently uploaded and we think we need time to have conclusions. Years ago this kind of material was in the Calculus book [3], but nowadays Java has problems with the most popular browsers and this makes it impossible to access and that's why we make this kind of videos.

## 5 CONCLUSIONS

At the Escola Tècnica Superior d'Enginyers de Camins Canals i Ports de Barcelona (ETSECCPB) the implementation of the new degrees implied a necessary review and improvement of the quality of teaching and learning activity. This change involves students to achieve specifically skills and abilities, like learning independently and communicate effectively. To achieve this goal, Calculus lecturers' team carried out different improvements.

The edition of the three collections of Calculus videos contributes to the CaminsOpenCourseWare project improving the quality of teaching activity and therefore the learning process of our students. The good reception concerning these audiovisual resources received from both academic staff and students make us feel optimistic about the video project. It allows us to think that our goal can be covered with guarantees if we continue enhancing this kind of resources. The best is that, if the student like to work, he work harder and better, so the engagement is the key to learn.

We really believe this is the way towards we have to continue working: editing audiovisual materials and using technological tools, as well as implementing the necessary materials that allow us to constantly enhance the innovation in mathematical teaching and learning practices.

We are sure that this line of work will be interesting to apply in many other subjects in both our university school and other schools or faculties.

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