# On the application of e-learning in engineering education

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## INTRODUCTION

E-Learning is a learning and teaching model that is designed to be carried out by using electronic media [1]. It is less expensive than the traditional learning approach, not limited to a specific geographic location and more flexible in terms of time. It is intended to replace the traditional learning in places where it cannot operate. While the computers make the learning easier, Internet technology acts as a communication bridge interconnecting other computers and people making the learning process interactive [2].

This paper is focused on the applications of e-learning in engineering education. The School of Engineering of the University Carlos III of Madrid has developed e-learning technologies for both distance and blended learning. The great technological possibilities of e-learning can be applied not only to distance education, but also face-to-face education can be enrich with online materials. Additionally, new pedagogical methodologies can be applied thanks to e-learning possibilities.

## 1 DISTANCE EDUCATION

The use of e-learning technologies in distance education has been applied for different purposes in the last few years: OpenCourseWare (OCW) and Massive Open Online Courses (MOOCs) provide greats opportunities for distance education. Free

educational materials are available to enhance engineering learning worldwide. Universities are using OCW and MOOC courses to spread their knowledge to thousands of students around the world.

OCWs are free course lessons offered by universities to any student. The University Carlos III of Madrid has offered 210 OCWs in 2014, receiving more than 600,000 visits from all around the world. This means a great international recognition of the institution.

In the last few years, a new generation of online courses has emerged: the MOOCs. The MOOCs include online lessons (videos and texts), exercises, forums and other tools to create a learning community around the online course. The University Carlos III of Madrid offers 6 courses in edX, one of the most prestigious MOOC platform, and 3 courses in MiriadaX, a MOOC platform focused on courses in Spanish and Portuguese.

The main purpose of this work is to explain how we have applied the acquired experience in the generation of online materials to improve the traditional classroom model in the School of Engineering of the University Carlos III of Madrid.

## 2 BLENDED LEARNING

Blended Learning is a learning model that combines traditional learning methods with online education materials. The face-to-face learning can be enriched with e-learning technologies to optimize classroom time and improve learning experiences [3].

The main goal of blended learning is the combination of face-to-face education and online education in an efficient way [4]. Face-to-face education provides interactive experiences while students can access to multimedia content at anytime, anywhere by benefiting from technology. This increases the scheduling flexibility of students.

The term “blended” includes the integration of e-learning and traditional learning but it has a broad meaning. The blend of these learning models depends on the needs of the students, the instructor requirements, and the institution facilities. When blended learning is understood and applied carefully, it will offer great advantage for students and teachers [5].

## 3 FLIPPED CLASSROOM

Blended learning used to be combined with the concept of “flipped classroom”. The flipped or inverted classroom refers to a learning design that overturns the typical division of student work [6]. Lectures are moved online to be viewed before class, and classroom time is dedicated to learning activities that require students to involve concepts at a higher level in a group setting and with an instructor at hand to answer questions, give feedback, and prompt reexamination of key ideas [7]. In the last years higher education standards have recognized the potential value of these student-centered learning environments where students are actively involved in higher-order tasks and taking charge of their own learning [8].

Several studies have shown that a flipped classroom can produce better learning outcomes as it increases levels of problem solving structure and practice [9,10]. Students benefit from the outside classroom events because they can allocate their time and pace their online learning to meet their individual levels of comprehension. In face-to-face classroom sessions, students have the opportunity to become more active and interactive through group activities rather than passively listening to lectures. Teachers, in turn, are able to commit more time in the classroom to monitoring student performance and providing adaptive and instant feedback to an individual or group of students [11].

The design of flipped classroom methodologies has often been limited to replace face-to-face lessons with videos and using class time for homework. However, the 'flipped classroom' is an open approach that facilitates interaction between students and teachers and differentiated learning [12] by means of flipping conventional events both inside and outside of the classroom and supporting them with digital technologies [13]. The use of learning technologies, particularly multimedia, provides new opportunities for students to learn, opportunities that are not possible with other media [14]

Institutionally, blended learning brings administrative advantages since theoretically it can reduce the need for time in the physical classroom and hence alleviate pressure on classroom scheduling [15]. Additionally, when contrasted with traditional lecture courses, student satisfaction tends to be higher in blended learning classes [16].

## 4 IMPLEMENTATION OF BLENDED LEARNING

The application of blended learning to improve engineering education requires facing numerous difficulties related to students, teaching staff, and institutions [17].

### 4.1 Institutions

Institutions have to create new facilities to produce online materials. Small Private Online Courses (SPOCs) can be used to organize blending learning. SPOC courses comprise of course materials supported with recorded lessons, flash animations, and evaluation (and self-evaluation) systems such as surveys, quizzes and peer-to-peer exercises.

The implementation of flipped classroom requires additional modifications of the institution facilities. Although these methods have certainly worked in traditional classrooms, the environment of a large lecture hall with fixed seating in rows makes peer collaboration difficult and awkward. A better environment for these pedagogies would be a room designed to facilitate small group work, such as an active learning classroom (ALC). These ALCs typically feature tables with moveable seating that support small group work. The net effect of the classroom design is to create a learning environment in support of active learning pedagogy and collaborative problem solving [7]. Additionally, in engineering education the laboratory classrooms with practical application of theoretical lessons is fundamental to develop the engineering skills, *Fig. 1*.

Empirical research on active learning classrooms was conducted on courses in physics education at North Carolina State University. Courses taught in active learning classrooms led to gains in students' conceptual understanding and improved attitudes than similar courses taught in traditional classrooms [18]. Similar gains were found in physics courses at the Massachusetts Institute of Technology [19]. Researchers have pointed out the importance of social interactions on how students developed their conceptual understanding in active environments.

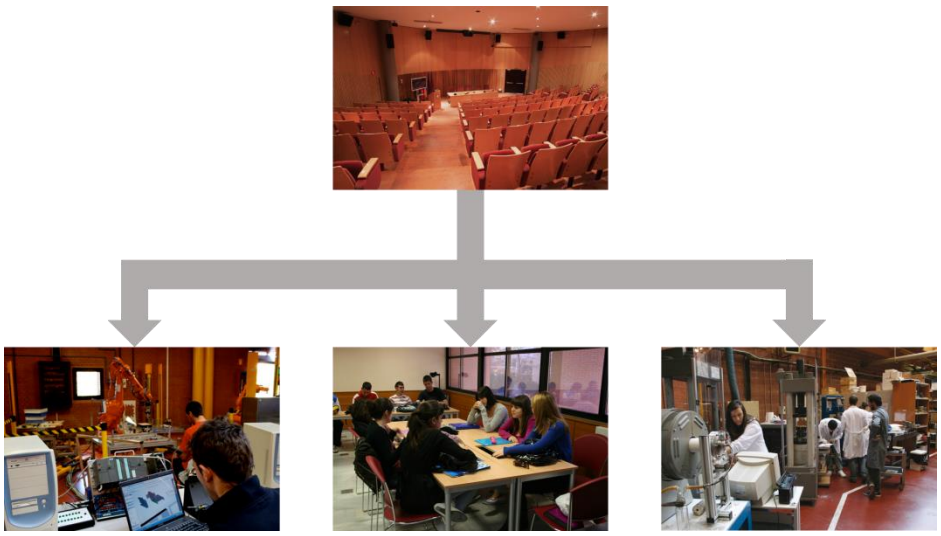

*Fig. 1.* Traditional classroom with fixed seating in rows can be replaced with active learning classrooms and laboratories.

Additionally, the institution has to consider that all the students must have free access to online contents. The financial capability of the students cannot be a requisite to access to the materials. Thus, institutions have to create classroom, or other spaces, where any student can have free internet access.

*Fig. 2.* Free internet access points for students.

However, the most important role of the institutions is the motivation of their teachers to collaborate in the development of these new methodologies.

### 4.2 Teachers

From the teacher point of view, blending learning requires an extra work. Teachers have to design and create online materials, to monitor students' progress, to include the e-learning technologies in the course programme, and to change the teaching methodology.

Student-centered learning environments necessitate applying more active learning strategies to classroom teaching. This involves, for example, student presentations, small group problem solving, self and peer evaluation, and group discussions.

Teachers are not necessarily prepared to apply new pedagogies or to support the expanded roles and responsibilities associated with student-centered learning. This is evidenced by challenges encountered in designing and supporting student-centered learning as was reported in [20,21]. For example, teachers are used to have difficulties on managing their reduced classroom time and limited number of face-to-face

classroom meetings to develop effective active learning strategies. Teachers who are going to include blending learning and flipped classroom in their courses need to acquire new teaching strategies.

### 4.3 Students

Blending learning implies a student-centred teaching method. The main advantages are that students are responsible for their learning process, their motivation is encouraged, and teachers can provide a more personalized attention to students.

One of the benefits of the flipped classroom is that students are able to prepare for face-to-face activities by on-line learning materials outside the classroom according to their own time schedules and levels of understanding. However, successful face-to-face interaction, in a typical flipped classroom, depends on the extent to which students have prepared before engaging with the in-class activities. If students had not prepared the face-to-face meeting, the advantages of the flipped classroom are reduced. Students must be compelled to make a different type of contribution to their own learning as they work through problems in class and teach each other.

## 5 EXAMPLE OF BLENDED COURSE

The School of Engineering of the University Carlos III of Madrid has implemented 9 blended courses combining online learning materials with face-to-face teaching. Five courses are designed for first-year students; they are dedicated on basic science (Physics, Mathematics and Chemistry). Four courses belong to engineering disciplines: Mechanics of Structures, Tissue Engineering, Computer Vision, and Programming. This section is focused on the description of the experience in the Mechanics of Structures Course.

This course is taken by students of four Bachelor degrees (Mechanical Engineering, Electrical Power Engineering, Industrial Electronics, and Industrial Technologies), this year the course was taken by 612 students.

The online materials offered to the students consisted on:

- 72 short videos with theoretical lectures about the main concepts and resolution of examples. The average length of the videos is 5 minutes, and the maximum duration is 10 minutes.
- 168 self-evaluation exercises.
- Discussion forum.

The face-to-face teaching was also modified thanks to the availability of the online materials. The teachers had more time to solve problems with the students and the learning method was more interactive. The involvement of the students was promoted, the theoretical lectures were replaced by design problems were students had to propose different solutions. For example, the students had to design and to build a truss made of spaghettis. The designs and the constructions of the spaghetti trusses were made by groups of three students, thus this activity, supervised by the teachers, lead to a collaborative learning.

The results of blended learning in this course were excellent:

- Online exercises: 52% of the students obtained more than a 90% of the maximum grade.
- Final grade: increased from 5.41 to 6.45.

However, the implementation of this course needed a great implication of the institution and the teachers. The institution supported the development of this project with facilities and staff. This was possible because a limited number of courses introduced blended learning, but it is not possible to adapt all the courses to this new methodology.

The teachers involved in this course dedicated a lot of time to the development of online materials, the forum administration and the preparation of face-to-face teaching with a new methodology. The opinion of the teacher is that blended learning works, but it requires much more time than classical teaching. The effort of this year dedicated to develop this course can be considered a good investment because online materials will be used during the next years. However, the feeling of the teacher is that the implementation of these methodologies rest on the dedication and the vocation of a group of teachers.

The students found blended learning a positive experience. They think that this methodology leads to a deeper understanding of the main concepts of the subject and to higher degrees. However, they felt that they had to do a lot of work every week.

## REFERENCES

[1] Bourne, J. R., Brodersen, A. J., Campbell, J. O., Dawant, M. M., and Shiavi, R. G. (1996). A Model for OnLine Learning Networks in Engineering Education. Journal of Engineering Education, 85(3), 253-262.

[2] Bell, B., & Federman, J. E. (2013). E-Learning Works--Exactly How Well Depends on Its Unique Features and Barriers: CAHRS ResearchLink No. 1. Center for Advanced Human Resource Studies, Cornell University.

[3] Kim, M. K., Kim, S. M., Khera, O., & Getman, J. (2014). The experience of three flipped classrooms in an urban university: an exploration of design principles. The Internet and Higher Education, 22, 37-50.

[4] Yigit, T., Koyun, A., Yuksel, A. S., & Cankaya, I. A. (2014). Evaluation of Blended Learning Approach in Computer Engineering Education. Procedia-Social and Behavioral Sciences, 141, 807-812.

[5] Lefoe, G. E., & Meyers, W. (2006). Modelling blended learning environments: Designing an academic development blog.

[6] Vignare, K. (2007). Review of literature, blended learning: Using ALN to change the classroom–will it work. Blended learning: Research perspectives, 37-63.

[7] Baepler, P., Walker, J. D., & Driessen, M. (2014). It's not about seat time: Blending, flipping, and efficiency in active learning classrooms. Computers & Education, 78, 227-236.

[8] Shea, P., Hayes, S., Smith, S. U., Vickers, J., Bidjerano, T., Pickett, A., ... & Jian, S. (2012). Learning presence: Additional research on a new conceptual element within the Community of Inquiry (CoI) framework. The Internet and Higher Education, 15(2), 89-95.

[9] Berrett, D. (2012). How 'flipping'the classroom can improve the traditional lecture. The chronicle of higher education, 12, 1-14.

[10] Missildine, K., Fountain, R., Summers, L., & Gosselin, K. (2013). Flipping the classroom to improve student performance and satisfaction. Journal of Nursing Education, 52(10), 597-599.

[11] Herreid, C. F., & Schiller, N. A. (2013). Case studies and the flipped classroom. Journal of College Science Teaching, 42(5), 62-66.

[12] Bergmann, J., Overmyer, J., & Wilie, B. (2011). The flipped class: Myths vs. Reality. The Daily Riff.

[13] Hughes, H. (2012, June). Introduction to flipping the college classroom. In World Conference on Educational Multimedia, Hypermedia and Telecommunications (Vol. 2012, No. 1, pp. 2434-2438).

[14] Lage, M. J., Platt, G. J., & Treglia, M. (2000). Inverting the classroom: A gateway to creating an inclusive learning environment. The Journal of Economic Education, 31(1), 30-43.

[15] Graham, C. R. (2013). Emerging practice and research in blended learning. Handbook of distance education, 3.

[16] Martínez-Caro, E., & Campuzano-Bolarín, F. (2011). Factors affecting students' satisfaction in engineering disciplines: traditional vs. blended approaches. European Journal of Engineering Education, 36(5), 473-483.

[17] Banday, M. T., Ahmed, M., & Jan, T. R. (2014). Applications of E-learning in engineering education: A case study. Procedia-Social and Behavioral Sciences, 123, 406-413.

[18] Beichner, R. J., Saul, J. M., Abbott, D. S., Morse, J., Deardorff, D., Allain, R. J., ... & Risley, J. S. (2007). The student-centered activities for large enrollment undergraduate programs (SCALE-UP) project. Research-based reform of university physics, 1(1), 2-39.

[19] Dori, Y. J., & Belcher, J. (2005). How does technology-enabled active learning affect undergraduate students' understanding of electromagnetism concepts?. The Journal of the Learning Sciences, 14(2), 243-279.

[20] Hannafin, M. J., Hill, J. R., & Land, S. M. (1997). Student-Centered Learning and Interactive Multimedia: Status, Issues, and Implications. Contemporary Education, 68(2), 94-97.

[21] Brush, T., & Saye, J. (2000). Implementation and evaluation of a student-centered learning unit: A case study. Educational technology research and development, 48(3), 79-100.