

Teaching structures on Architecture degrees. ICT-based methodology and teaching innovation

La enseñanza de las estructuras en el Grado de Arquitectura. Metodología e innovación docente a través de las TIC

Jonathan RUIZ-JARAMILLO, PhD. Assistant Professor. Universidad de Málaga (jonaruizjara@uma.es).

Antonio VARGAS-YÁÑEZ, PhD. Lecturer. Universidad de Málaga (antoniovy@uma.es).

Abstract:

The teaching of structures on architecture degrees has traditionally been based on didactic lectures covering theoretical content with exercises solved in class by the lecturer. This very passive teaching style which involves minimal student participation, was accompanied by a high failure rate. Based around calculating unrealistic models by hand, this method is unattractive from a pedagogical perspective, something reflected in low attendance rates. It also creates superficial learning in which concepts are quickly forgotten after finishing the module. This article presents the innovations adopted in the Structures II and Structures IV modules from the Architecture degree at the University of Malaga, which have made it possible to raise the pass rate and attendance, and also aim to give students a closer link to this content through the use of ICT. To do this, flipped learning and PBL methodologies were used along with various ICT tools that also made it possible to check how students follow the module with the aim of evaluating the results of continuous assessment.

The results obtained show a rising trend in the pass rate with an improvement in the quality of the passes and an increase in the number of students who sit the exam in the first assessment period. It can be concluded that the use of the methodology described above leads to students being more involved and motivated by the subject, favouring continuous weekly work, and thus achieving better learning.

Keywords: teaching, teaching methods, ICT, PBL, flipped classroom, structures.

Resumen:

La docencia de las estructuras en el Grado de Arquitectura se ha basado tradicionalmente en la lección magistral de contenido teórico junto a ejercicios resueltos en clase por el profesor. Esta docencia, muy estática y con mínima participación del alumnado, iba además acompañada de una tasa de suspensos elevada. Centrada en el cálculo a mano de modelos poco reales, no resulta atractiva

Revision accepted: 2018-01-31.

Cite this article as: Ruiz-Jaramillo, J., & Vargas-Yañez, A. (2018). La enseñanza de las estructuras en el Grado de Arquitectura. Metodología e innovación docente a través de las TIC | *Teaching structures on Architecture degrees. ICT-based methodology and teaching innovation*. *Revista Española de Pedagogía*, 76 (270), 353-372. doi: <https://doi.org/10.22550/REP76-2-2018-08>

desde el punto de vista pedagógico, algo que se manifiesta en el escaso porcentaje de asistencia, generando además un aprendizaje poco profundo cuyos conceptos se olvidan en poco tiempo tras superar la asignatura. El siguiente artículo presenta las innovaciones adoptadas en las asignaturas de Estructuras II y Estructuras IV en el Grado de Arquitectura de la Universidad de Málaga, con cuya aplicación se ha conseguido elevar tanto el índice de aprobados como el porcentaje de asistencia, buscando estrechar además, por medio del uso de las TIC, la relación del estudiante con estas materias. Así, se han utilizado metodologías del tipo docencia invertida o *flipped learning* y ABP, empleando para ello diversas herramientas TIC que, adicionalmente, han permitido comprobar

el seguimiento de la asignatura a efectos de valorar los resultados de la evaluación continua.

Los resultados obtenidos ponen de manifiesto la tendencia ascendente en el índice de aprobados, así como en la calidad de estos, consiguiéndose asimismo un incremento en el número de alumnos que se presentan en primera convocatoria. Se puede concluir que el uso de la metodología enunciada conlleva una mayor implicación y motivación del estudiante con la materia, favoreciendo el trabajo continuo semanal, logrando con ello un mejor aprendizaje.

Descriptor: docencia, técnica didáctica, TIC, ABP, *flipped classroom*, estructuras.

1. Introduction

Owing to its significant theory content the teaching of structures on Architecture degrees, has traditionally been based almost exclusively on the didactic lecture format. In this format, the more purely theoretical content was complemented by exercises the lecturer solved mechanically on the board. In addition, it is worth emphasising the focus on practical work that is present most of the time. This usually comprises exercises that do not have a clear application to reality or have little direct application to the professional practice students will enter after completing their studies. However, it is precisely these theory modules that should have the closest connection to reality (Monedero-Moya, 1998).

This system, based on calculation by hand using unrealistic models, generated a success rate of 35%, and an attendance rate of 25% (Justo Moscardo, 2013). This methodology is so deeply-rooted that, even after the creation of the European Higher Education Area (EHEA) and the introduction of the new Bologna syllabuses, most of the educational innovation initiatives in this area focussed only on reviewing the theoretical and practical materials available to the students. In other words, preparing and publishing module notes or turning them into slide shows (Pomares Torres et al., 2016).

Even with this procedure being the most commonly used methodology, over time different innovation pathways have gradually developed. One of the most common has been to find the underlying

ing transversality of content across related subjects, encouraging cooperative and transversal learning alongside other modules. In the case of teaching on architecture degrees, the logic of architectural design makes it possible to identify transversal content by creating joint seminars between project-based and technical modules, such as projects, structures, and construction, either vertically across different years (Pérez Carramiñana et al., 2010) or between modules in the same year.

Another pathway explored is to connect the teaching activities performed in the classroom with research, allowing students to learn by experimenting with new structural solutions and systems, either by designing and calculating models (Escrig Pallarés, 1994) or through their own construction work by making prototypes and models (Pérez-Sánchez, Piedecausa-García, Mateo Vicente, & Palma Sellés, 2015). Accordingly, it is of interest to develop interactive models to represent the behaviour of real structures such as Pasco or Mola Structural Kits or hold contests to break structural models of doorways, beams, and grates such as those organised by the Building Materials Laboratory at the Polytechnic School at the San Pablo CEU University or, at an international level, the ones organised by The Institution of Structural Engineers (Lonnman, 2000).

Nonetheless, although the methodologies mentioned above are of great interest, are effective, and deliver good results, Problem-Based Learning (PBL) has the greatest potential and scope for application, especially from the perspective of

«Bologna» generation syllabuses. Indeed, PBL has started to be integrated into the new syllabuses, taking advantage of the framework created by the EHEA, with the basic objectives of raising the success rate on technical modules and creating a setting where the student's interest in these subjects increases.

To achieve this, the process starts by presenting a problem to the students, who, generally working in groups, then try to solve it. During the analysis, learning and comprehension of the problem are generated as well as further work on solving the exercise. In this way, the students start by tackling the problem, not the theory they will use to solve the challenges that arise during the process (Barrows & Tamblyn, 1980). The students work autonomously, although they have the support of the tutor who acts as a guide for the process. When designing the problem, it is necessary to ensure that it cannot have one single answer, so that students identify what it is they need to learn to solve the problem. Consequently, depending on their knowledge, they can apply different strategies and gradually reflect on their effectiveness (Hmelo-Silver, 2004).

The main objectives that can be achieved by using this methodology are: more structured knowledge to apply to real settings and cases; developing an effective applied thinking process; creating greater student autonomy through self-directed learning; improvement in the competencies associated with collaborative work; and increasing motivation in the subject (Barrows, 1986). Achieving these objectives is linked to

a series of mechanisms that facilitate knowledge acquisition such as activating and structuring prior knowledge or how information is developed (R. Schmidt, 1983). This type of methodology sets in motion processes that lead to in-depth learning through a particular codification which means that the skills are subsequently recovered with greater ease when the individual encounters similar situations. This last question is not insignificant, as one of the main problems associated with teaching structures is continuity in what is learnt. Indeed, in most cases, students tend to forget most of the material studied progressively and quickly after they have sat and passed the corresponding assessment exam.

2. Applying technology to teaching

It is clear that teaching, especially at university level, cannot ignore how technology has become exponentially more important in our lives since the final years of the twentieth century. It has influenced university teaching in two main ways. On the one hand, teaching processes have increasingly integrated technologies. On the other hand, there is the habitual and necessary use of computers applied to the different architectural creation processes, ranging from the facets most closely linked to design, to the techniques associated with calculating structures, installations, and verifying compliance with certain features of building. Throughout this process, the training of teachers in applying ICT to teaching is vital (Tejedor Tejedor & García-Valcárcel Muñoz-Repi-so, 2006).

2.1. Technology applied in the classroom

Concerning the growing role of technology in teaching, the process has two aspects. In the first, technology has a direct influence on face-to-face teaching through its increased importance in classroom space. The appearance in the classroom of computers and projectors led to the progressive disappearance of the old transparencies and overhead projectors, and also condemned traditional slides to obsolescence. These were all replaced by PowerPoint type slides, reducing the common use of the board in explanations to a bare minimum.

As a result, this apparent digital revolution in the classroom led to teachers bombarding students with excessive slides during their lectures. The students thus became passive receptors of information, something that soon led to expressions like «death by PowerPoint» being coined, reflecting how this methodology bored audiences. The traditional attention curve shows that, if there are no significant changes in the form or the lecturer's discourse, students will generally maintain focus for 10 to 15 minutes with a traditional teaching style (Stuart & Rutherford, 1978). Introducing these new tools has meant that, far from improving and extending students' attention, the maximum attention benchmark has not even remained stable but has started falling. Students could, in effect, at least «entertain» themselves by taking notes in the past (Wilson & Korn, 2007). This has had an inexorable and unavoidable secondary consequence: a drastic reduction in the number of students who regularly attend face-to-face classes.

The prominence of technology in the classroom has grown in recent years, linked to the introduction of technological elements such as interactive whiteboards, although this is not the only course of action. These are ultimately initiatives aimed at improving the lecturer's interaction with students by

modifying the dynamic of classes, and so the purely technological additions are complemented by others that affect the very concept of the teaching space, ranging from changes with furniture (Image 1) to the form of its boundaries (Campos Calvo-Sotelo, 2009; Campos Calvo-Sotelo, 2010).

IMAGE 1. Inclusion of interactive whiteboards and modification of classroom furniture during the 2016-2017 academic year in the Higher Technical School of Architecture at the University of Málaga. The image on the left shows the previous rigid distribution of the seating in the classroom.



Source: Own elaboration.

2.2. Technology applied to productive processes

Along the same lines, in the field of engineering and architecture, the use of specific computer tools and applications and calculation procedures to streamline and simplify the work of professionals and technicians has become widespread.

The *softwarization* and *appification* of the work and personal spheres, in other words including Information and Communication Technologies (ICT) in all areas of

our lives, has a direct impact on teaching. Teaching methods are often modified to introduce these procedures and systems, often applying them to calculation and so, paradoxically, introducing a distortion. The majority use of computer calculation programs means that students learn to use a particular piece of software while neglecting the theoretical foundations underpinning it and so they lose the ability to analyse the initial problem and the essential skills for interpreting the results, which they accept uncritically.

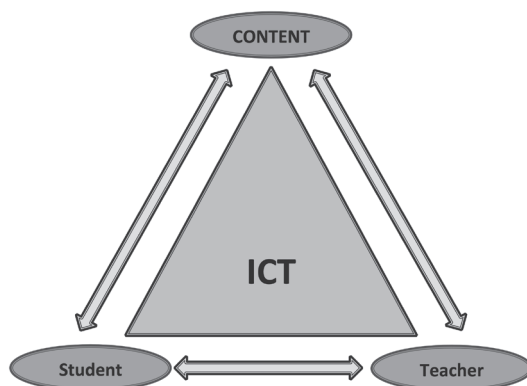
This is how the dichotomy arises between, on the one hand, teaching computer-based analysis and calculation procedures to train students in technologies they will subsequently apply in their professional life and, on the other, the need to create a solid foundation based on the theoretical knowledge that is needed to understand the phenomena on which they are working.

The integration of ICT in university teaching makes sense in this dual framework. Its ubiquity means it can be introduced naturally as a tool to support teaching and classroom teaching systems to motivate students and enliven teaching tasks. Their involvement is not just focussed on the case of using tools through the virtual campus for the modules, but it also affects the actual use of applications that develop the content and link learning to professional practice.

The gradual integration of ICT has provided fundamental support for the application and development of the different

teaching methodologies we have been discussing (Escardibul & Mediavilla, 2016). This has not exclusively been limited to simply publishing the different content areas of the modules online. In contrast, there are many examples that emphasise the positive impact of using ICT resources as learning tools (De Pablos Pons & Jiménez Cortés, 2007; Pérez-Sánchez, Piedecausa-García, Pérez Sánchez, Mora García, & Céspedes López, 2016; Salinas, 2004; Vélez Flores, 2015). One of the most interesting of them is the use of ICT in PBL (Badia & García, 2006; Farnos, 2011). In effect, the possibilities for developing the teaching-learning process through the problem-based learning methodology offered by using ICT are many and varied (Graph 1). On the one hand, these technologies make it possible to establish fluid and dynamic relationships between students and teachers and between the lecturers and the content of the subject to be delivered. Similarly, depending on the type of tools to be used, they give independent support to teachers and students alike.

GRAPH 1. Relationship between ICT and the different factors involved in the teaching-learning process.



Source: Own elaboration.

3. Educational innovation in teaching about structures: application to the module Structures II

3.1. Description of the methodology used

Owing to the gradual process of implementation of the new Architecture degree syllabus, delivery of this module started in the 2012-2013 academic year. It is equivalent in credits, face-to-face teaching hours, and its programme to the module from the previous syllabus, the only difference between them being the teaching innova-

tion that is described below, given that the teaching on the previous one was solely based around didactic lectures. Specifically, at the level of content, the teaching programme covers the calculation of forces in framework structures, both in triangulated structures (trusses) and in grid structures (frames). The module is worth 6 ECTS credits, equivalent to 150 hours of work by the student, 60 of these being in class and 90 outside of class. As the semester has 15 teaching weeks, the weekly work load outside class for students is 6 hours.

IMAGE 2. Example of a practical question sheet with time limit included in the module's virtual campus.

Start again

The students will see this quiz in a secure window

Note: Your students cannot access this quiz at this time

1 Points: 1

Indicate which lines in the following structure have a perfect fixed end moment
(points are deducted for incorrect answers)

Select at least one answer. There may be more than one correct answer.

- ☐ AD
- ☐ BE
- ☐ FG
- ☐ CG
- ☐ DE
- ☐ EF

Source: Own elaboration.

At a methodological level, compared with its counterpart in the previous syllabus where teaching was based exclusively on didactic lectures, it features pedagog-

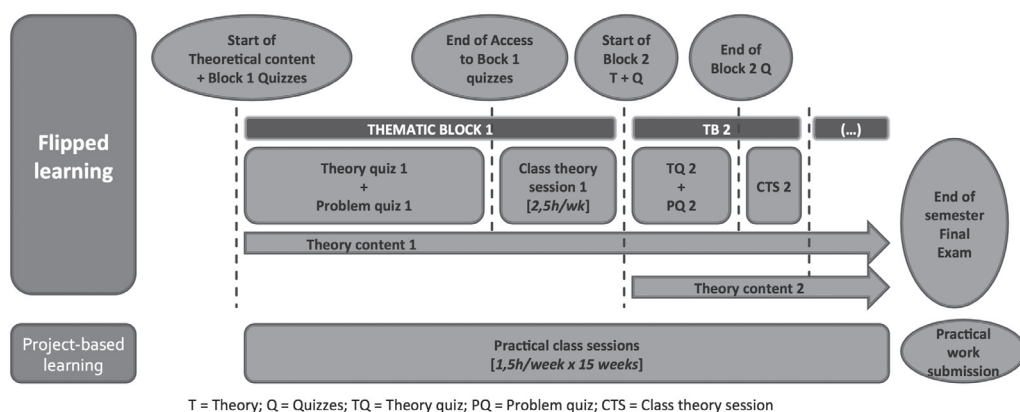
ical innovation. This partly comprises the introduction of a system of continuous assessment that enables and facilitates weekly monitoring of the module's

content. So, through the virtual campus, the student should complete online question sheets every week. These, on the one hand, help revise and reinforce the theoretical content and, on the other, they allow for the exercises and problems to be completed and assessed by applying the theory (Ruiz-Jaramillo, Mascort-Albea, & Vargas-Yáñez, 2015). Consequently, there is one group of question sheets directly linked to the theory content and another group, which despite having a similar function, allows for the monitoring and

evaluation of the weekly problems and exercises linked to the theory (Image 2).

As for scheduling during the semester, access to the different types of content, question sheets, and related exercises is programmed weekly to encourage constant interaction with the module. Consequently, the student can only do the exercises for a topic in a specific week. After that, they will have access to the theory content but will not be able to answer the question sheets. This distribution is shown in Graph 2.

GRAPH 2. Outline of the weekly time distribution of the activities planned throughout the semester and the methodology used.



Source: Own elaboration.

All of the blocks of theory in the module are based on the methodology known as *flipped classroom*. In this method, students attend the face-to-face classes having previously reviewed the planned content and once in class, the lecturer emphasizes and/or covers in depth the questions deemed especially relevant, the most difficult ones or ones that the

students themselves choose as they are more interesting or complex (Mok, 2014; Uzunboyly, 2015). Flipping the classroom appears sound: passive learning activities such as unidirectional lectures are pushed to outside class hours in the form of videos, and precious class time is spent on active learning activities. Yet the courses for information systems (IS).

This methodology means that, in contrast to what happened with didactic lectures that rely on the board and slides, students must play an active role in their learning as they must prepare the topics before the theory classes. This will facilitate their comprehension and enable them to obtain the maximum benefit (Hall & Dufrene, 2016; Ozdamli & Gulsum, 2016; S. M. P. Schmidt & Ralph, 2016).

The planned distribution of hours by classroom and non-classroom activities

(Table 1) shows that if they set aside 2 hours per week of non-classroom work in preparation for the final exam, students should dedicate 4 hours per week to preparing for the theory classes and studying the subject. In this plan, it should be noted that a student who duly follows the course could reduce the estimated figure of 30 hours preparing for the final exam, given that this should comprise reviewing/revising what was learnt/covered during the 15 weeks of the semester.

TABLE 1. Plan for student’s work on the different activities throughout the semester, assuming a standard length of 15 weeks for the semester for purposes of calculation and estimation.

Module	6 ECTS credits	150 hours of student work	60 hours in class 90 hours out of class
1 ECTS credit → 25 hours of student work			
Activities in class		Activities outside class	
Large group teaching (theory)	2.5 h/w. (37.5 h).	Preparing for final exam	2 h/w. (30 h).
Small group teaching (practice)	1.5 h/w. (22.5 h).	Preparing for face-to-face classes (<i>Theory questions + exercises</i>)	4 h/w. (60 h).
(*) The anticipated 30 hours would be equivalent to 3 days of work preparing for the exam, as two 5-hour sessions per day.			

Source: Own elaboration.

Although there is ample experience of applying this methodology to teaching in various disciplines (Barreras Gómez, 2016; Gómez García, Castro-Lemus, & Toledo Morales, 2015; Wasserman, Quint, Norris, & Carr, 2017), its use in teaching architecture is not common. The most

recent studies indicate that this methodology is especially recommended for professions with a high technical content that must subsequently be applied in professional life (Baytiyeh, 2017), which suggests that its use is especially appropriate for teaching about structures.

As students must have all of the information and resources before the theory class so they can apply them, this system is inextricably linked to the use of ICT (Mendoza, 2015). This is not just a set of tools that allow access to information; it also enables students to evaluate their own progress and performance in the module, making it possible for these activities to be incorporated as continuous assessment, forming part of the final mark for the module.

Regarding *flipped learning*, one matter that should not be ignored is its close link to e-learning teaching (Anderson & Garrison, 2010), this being the platform for much of the methodology used in distance courses using online platforms (Massive Open Online Course-MOOC). Similarly, this type of teaching can be regarded as one of the tools capable of complementing PBL (Tawfik & Lilly, 2015). In effect, in the case of the Structures II module we are analysing, its application to the learning of theory has a supplement based on the PBL methodology used in the practical work that is done throughout the semester.

In this way, completing a piece of practical coursework is introduced in the practical blocks that complement the more theoretical teaching and where students apply holistically what they learn in the theory blocks.

To do this, they take a detached house developed in previous years and integrate the structural system so that it covers both of the structural types included in the course content and then proceed to work out the forces on the structure's different bars.

This process enables the student to visualise clearly the practical utility of the content of the module by applying it to solving design problems in a real structure. The students do this during the weekly practical sessions where the lecturers review the work and answer questions that arise. The type of work, its extension, and its scope, means that it can be done during the 22.5 hours (1.5 hours $\times$ 15 weeks) of practical class-based work so that the student does not spend time working on this outside class. In this way, observing the planning of the students' weekly dedication (Table 1), it can be said that this is sufficiently measured in the course as a whole.

The development of this work is, therefore, based on the use of PBL methodology as the practical work directly confronts students with a problem they themselves have raised (an architecture project) which they will work on, modifying it to meet the requirements of the specification. At the start they do not have the necessary competencies to do this; these are acquired during the successive advances both in their own work and in the theory classes, thus connecting the two blocks. Doing the practical work therefore, takes into account the process and basic principles of PBL (Justo Moscardo, 2013).

3.2. Evaluation

Regarding evaluation, in addition to the assessments mentioned above, there is a final exam in which students solve similar theory and practice exercises to the ones they do during rest of the course. The value and percentage of the final mark of each of these tests is shown in Table 2.

TABLE 2. Value and percentage of the final mark of each of the evaluation activities of the Structures II module from the degree in Architecture.

Evaluation activity	Value	% final mark
Theory question sheets (weekly)	0.5	+ 5.0 %
Problem question sheets (weekly)	1.0	+ 10.0 %
Mid-term exam (triangulated structures)	0.5	+ 5.0 %
Participation (in class, virtual campus forums, etc.)	0.5	+ 5.0 %
Structural design practical work (designing and calculating a detached house)	0.5	5.0 %
Final exam (requirement: a minimum of 3.5 points)	10	95.0 %
	13.0	100 %

Source: Own elaboration.

The course practical work and the final exam are the only assessments it is compulsory to submit in order to pass. So, a student who does not wish to do the continuous assessment is not penalised for this and can pass by obtaining the highest mark. However, it is necessary to note that obtaining a minimum of 2.5 points on the final exam –equivalent to 19.2% of the total course evaluation– is a prerequisite. This requirement means that students must show they have acquired minimum knowledge and competences in each of the thematic blocks.

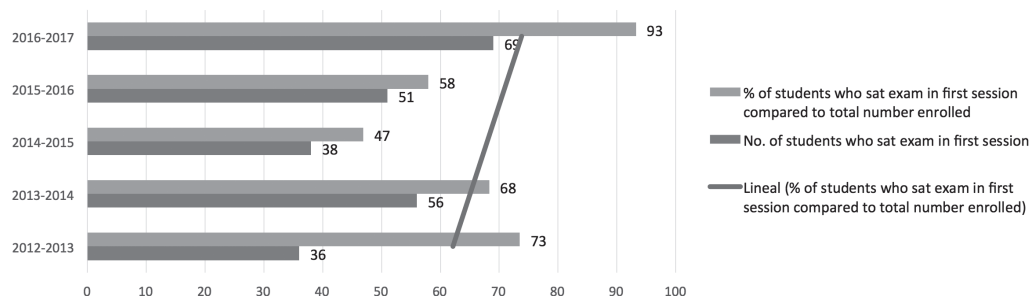
The other assessments are voluntary. The marks from them are extra credit in addition to that obtained in the compulsory tests. So the weekly evaluation question sheets, which include theory and practical exercises (for example, estimating force diagrams), active participation and interest in class and forums, as well as completing a mid-term exam at the end of one of the module's content blocks are suggested as extra points that the student adds and that provide an incentive to follow the course

every week. In effect, as can be seen, if a student obtains the minimum mark in the final exam (2.5 points), the continuous assessment exercises allow him or her to pass the module even if the final exam is failed, as with the other weekly exercises and the practicals it is possible to add as many as 3.0 points to the mark from the final exam. Similarly, they make it relatively easy to get a mark of good or excellent.

3.3. Results obtained

From the perspective of academic results, the use of this methodology has a double aim: firstly, to increase the success rate at the first attempt, which it does through the significant use of continuous assessment, and secondly to raise the overall success rate. Accordingly, we can see that the percentage of students who take the assessment in the first session has a progressively increasing trend (Graph 3). Indeed, the percentage of people who sat the test in the most recent session was 93%.

GRAPH 3. Percentage of students who sat the exam for the Structures II module in the first session. The trend line for the percentage of people sitting the exam in the first session is shown.

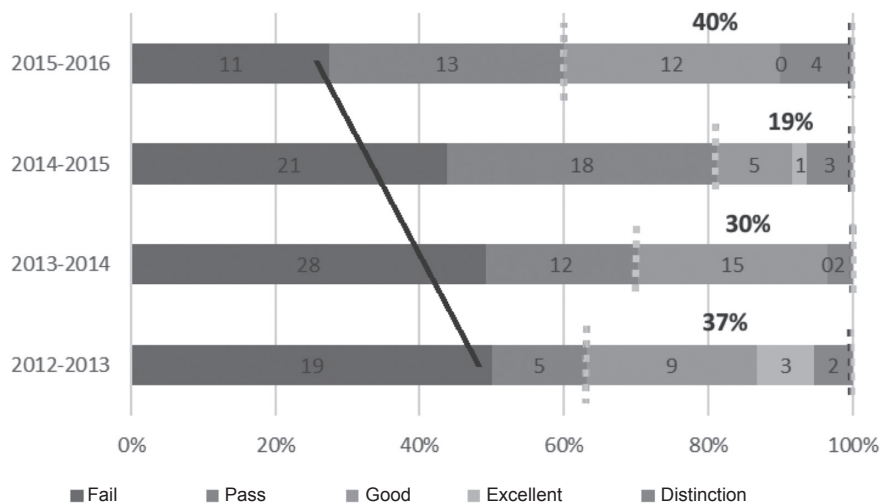


Source: Own elaboration.

As well as this increasing trend in the number of people per year who sit the exam in the first session, if the total percentage of pass marks per course is con-

sidered, Graph 4 shows that this displays a substantial increase from 50% in the first year the module was delivered up to around 73% in 2015-2016.

GRAPH 4. Percentage of different grades obtained in the Structures II module by academic year. The trend line for the percentage of fails is shown. The percentage of students who successfully completed the module with a mark higher than pass is shown.



Source: Own elaboration.

On the other hand, regarding the grades, Graph 4 shows that the average mark of the people passing the module with a grade higher than a pass is 31%. If we compare the trend in both images, it is apparent that in years when more people took the exam (in other words, years when a larger number of students took the module), the percentage of students who obtain a mark of good or better also increases. Therefore, it is possible to conclude that with the proposed methodology there are not just fewer fails; instead the rate of success increases with the percentage of candidates who get a mark higher than pass increasing.

4. Educational innovation in teaching about structures: application to the module Structures IV

4.1. Description of the methodology used

A similar methodology to the one described above is used in the Structures IV module from the same course. However, while it does follow a similar methodology to the one described, there are some differences in this case. The aim of presenting different procedures is that as these are applied on modules with similar technical content, it is possible to compare the results obtained by using each methodology.

Specifically, the content of this module focusses on the design and dimensioning of steel and reinforced concrete structures based on calculations of stresses resulting from different forces. The learning out-

comes are based around knowledge of the specifications contained in the different regulations in force under Spanish and European legislation regarding structural calculations.

In the case that interests us, teaching is structured around a weekly didactic lecture that combines theory and practice, encouraging student participation during the session. Exercises are then proposed in the practical class to complement each of the topics the students have to solve during the class. Unlike in the previous case, the *flipped classroom* methodology is not directly used since, while the students do have the information ahead of the theory class, there is no prior coverage of the subject with the preparatory question sheets.

In this case, ICT resources are used as support for the theory content. To incorporate the work, the students perform outside class into the normal dynamic of the module, a series of activities are prepared with content that varies according to the subject with which they are associated. These range from ordinary online question sheets, for solving exercises or evaluating theory, up to SCORM type presentations. These video format interactive presentations can include questionnaires or activities for revising or reinforcing learning of the content being viewed (Gonzalez-Barbone & Anido-Rifon, 2008; Papazoglakis, 2013) the creation of really reusable, searchable learning objects requires a detailed consideration of metadata, where some institutional aspects may be unclear or not available. This work describes creation

of a first learning object, from software tools installation to final packaging. It aims at a wider perspective than that offered by handbooks or user guides for content generation tools, generally poor or altogether deprived of suggestions on how to go about to achieve reusability, interoperability, durability and accessibility as conceived by the SCORM standard. Only free software and Internet publications are used as references. The creation of a simple SCORM package with the Reload Editor is described step by step, and the package created is then tested using Reload SCORM Player, allowing for the detection of some difficulties and alternatives of solution. Help available and some commented references are afterwards indicated. A list of suggestions finally emerges, to the purpose of solving beforehand most of the uncertainties, defining a consistent learning object creation scheme and reducing training time to master tools and metadata generation. As a conclusion, some limitations found along the work are pointed out, in particular the necessity of adopting or defining a LOM (Learning Object Metadata). They have the additional advantage that they can be viewed on any platform, and so they are easily accessible, for example, on mobile devices such as telephones or tablets.

As well as these online resources for free revision of the subject, explanatory videos are also prepared to cover concepts/solve exercises (Guo, Kim, & Rubin, 2014).

To complement the theory blocks, the students have to do practical coursework in groups of 3 where they progressively apply the concepts presented in class. This practical work makes it possible to apply the PBL methodology described above. Each of the work groups has to operate as a small consultancy entrusted with calculating the structure of the project chosen from the range proposed by the lecturer. For example, during the 2016-2017 academic year, a set of paradigmatic dwellings representing 20th century architecture built with steel structures was used as the theme for the work. Monitoring of practical work partly takes place face-to-face in the small group classes, as well as during the tutor hours and also happens continuously and outside class using ICT tools such as the specific forums for each group.

4.2. Evaluation

In this case, the evaluation was based on the different tests performed during the year. The value and percentage of the final mark of each of these tests is shown in Table 3.

TABLE 3. Value and percentage of the final mark of each of the evaluation activities of the Structures IV module from the degree in Architecture.

Evaluation activity	Value	% final mark
Mid-term exam on Steel structures	1.5	15.0%
Mid-term exam on Concrete structures	1.5	15.0%
Structural design practical work (structural design, calculating action, and calculating combinations and enclosures)	1.0	10.0%
Final exam (requirement: a minimum of 1.0 point in each of the content blocks)	6	60%
	10.0	100%

Source: Own elaboration.

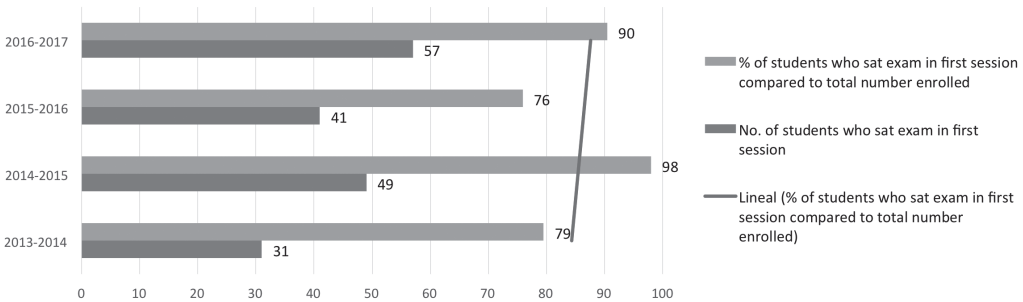
This is the most important difference compared with the Structures II module. Here, the continuous assessment is based on two mid-term exams during the semester, each of which is about one of the blocks from the list of topics. The mark from these exams, which are worth 15% of the final mark, is kept until the second ordinary exam session (September). This provides additional motivation for the student to follow the module weekly. On the other hand, as in the Structures II module, it is specified that students must attain a minimum mark in the final exam

to show that they have acquired minimum levels of knowledge and competencies in each of the thematic blocks.

4.3. Results obtained

Analysis of the number of students who sat the exam in the first session in the different years that this module has been delivered (Graph 5) shows that progression has a slight upward trend although it could not be considered especially low in any of the years.

GRAPH 5. Percentage of students who sat the exam for the Structures IV module in the first session.

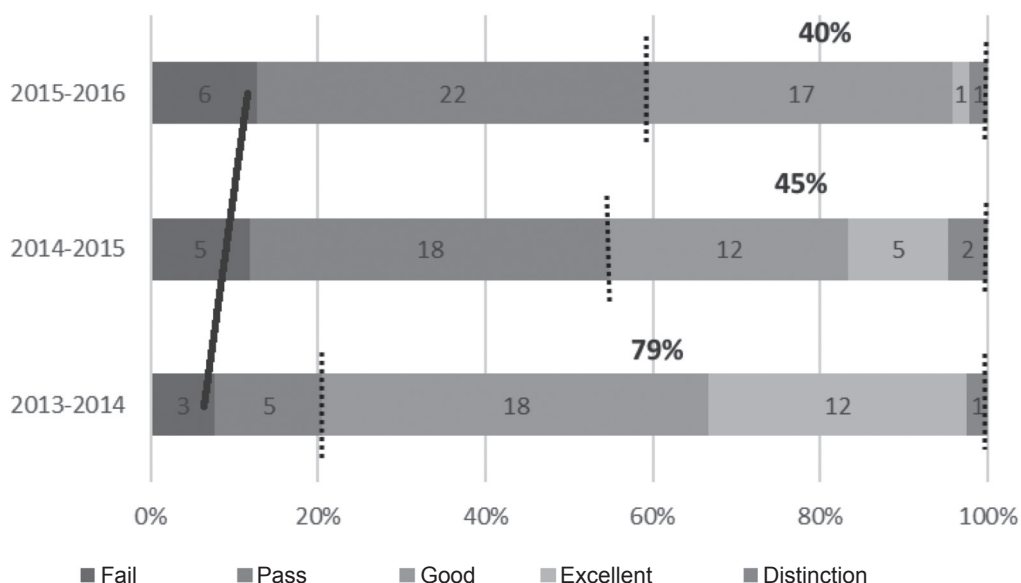


Source: Own elaboration.

From the point of view of qualifications, Graph 6 shows both the percentage of fails in the years completed since the start of this module and the percentages

of other grades (pass, good, excellent, and distinction), and also shows the percentage of students obtaining a grade of good or above.

GRAPH 6. Percentage of different grades obtained in the Structures IV module by academic year. The trend line for the percentage of fails is shown. The percentage of students who successfully completed the module with a mark higher than a pass is shown.



Source: Own elaboration.

As is apparent, there is a slight increase in the percentage of fails, from 7.7% in 2013-2014 to 12.8% in 2015-2016. Likewise, a fall in the number of students who get a mark higher than a pass can be seen, going from 79% to 40%, with the outcome that the percentage of students who successfully complete the module with a pass mark increases.

5. The beneficiary of innovation: the student perspective

From the perspective of ICT use, to evaluate students' views of the innovations included in the respective modules, a question about the use of the different resources and media in face-to-face lessons and in the various activities offered through the virtual campus has been included in the student opinion surveys. From the different answers it is possible to infer that

the innovations implemented —such as videos, SCORM presentations, and on-line questionnaires— are all very highly appreciated, although the inclusion of a large amount of material in the virtual campus is sometimes seen as a lack of organisation. In contrast, it is interesting to note that presentations with slides are not particularly well valued, while using a similar medium like the board is highly valued.

As for the use of PBL, the opinion surveys that students completed for both modules give practically identical results: it gives students considerable motivation as they see how the knowledge they acquire can be applied to real situations. However, they believe that the effort of doing the practical work is not adequately reflected in the final mark, given that its weight in the evaluation is somewhat lower than the weighting for the final exam.

6. Conclusions

The results obtained make it possible to conclude that the methodology of continuous assessment through weekly evaluations combined with the use of the *flipped classroom* technique make it easier to follow the module during the semester and also enable students to easily reach the minimum standards required to complete the module successfully without increasing their workload. This is shown by the increased number of students who take the exam in the first session. Furthermore, from the point of view of results, increases in the absolute number of passes per year and in the per-

centage of students who obtain a mark higher than good can be seen. In other words, compared to using a more static or traditional methodology, flipped learning combined with continuous assessment through ICT and PBL leads to more pass marks and these are also of a higher quality.

This increase in performance is also accompanied by the students' own perception of the improvement in learning as a result of the innovations introduced. Consequently, the use of the PBL methodology by applying the knowledge being acquired to a real structure leads to high levels of motivation, although, in the opinion of the students, the dedication required should be reflected by an increase in its weighting in the final mark. In addition, using ICT increases students' motivation in the subject, although during face-to-face classes the use of resources such as the board turns out to be more popular than the technological innovation of presentations with slides.

With this in mind, we can conclude with a reflection. As we are caught up in the multitude of changes linked to the speed at which our lives progress, will screen fatigue lead us to combine our dependence on them with a return to the «old, manual, slow activities, from our grandparents' era»? (Bueno, 2017)¹.

Notes

¹ This document was prepared in the framework of the educational innovation project called «New teaching frameworks: ICT applied to problem-based learning in the teaching of technical

qualifications» (PIE15-166) funded by the Universidad de Málaga and undertaken during the 2015-2016 and 2016-2017 academic years.

References

- Anderson, T., & Garrison, D. R. (2010). *El e-learning en el siglo XXI. Investigación y práctica*. Barcelona: Octaedro.
- Badia, A., & García, C. (2006). Incorporación de las TIC en la enseñanza y el aprendizaje basados en la elaboración colaborativa de proyectos. *Revista Universidad y Sociedad Del Conocimiento*, 3 (2), 42-54.
- Barreras Gómez, M. A. (2016). A flipped-classroom experience in Didactics of Foreign Language. *Educatio Siglo XXI*, 34 (1), 173-195.
- Barrows, H. (1986). A Taxonomy of problem-based learning methods. *Medical Education*, 20, 481-486.
- Barrows, H., & Tamblyn, R. (1980). *Problem-Based Learning: An Approach to Medical Education*. New York: Springer.
- Baytiyeh, H. (2017). The International Journal of Information and Learning Technology The flipped classroom model: when technology enhances professional skills. *The International Journal of Information and Learning Technology Industrial and Commercial Training Iss International Journal of Information and Learning Technology*, 34 (1), 51-62.
- Bueno, J. (2017). *La sociedad que seremos*. Madrid: Cadena Ser. Retrieved from http://cadenaser.com/programa/2017/06/07/hoy_por_hoy/1496816341_747703.html
- Campos Calvo-Sotelo, P. (2009). La Educación, un hecho espacial. El «Campus Didáctico» como arquitectura para el Espacio Europeo de Educación Superior. *La Cuestión Universitaria*, 5, 98-120.
- Campos Calvo-Sotelo, P. (2010). 10 principles for an innovative model for the 21st century university: «the educational campus». *Aula: Revista de Pedagogía de La Universidad de Salamanca*, 16, 187-200.
- De Justo Moscardo, E. (2013). *Diseño y evaluación de un programa para el aprendizaje de estructuras de edificación mediante ABP*. Sevilla: Universidad de Sevilla.
- De Pablos Pons, J., & Jiménez Cortés, R. (2007). Buenas prácticas con TIC apoyadas en las políticas educativas: claves conceptuales y derivaciones para la formación en competencias ECTS. *Revista Latinoamericana de Tecnología Educativa*, 6 (2), 15-28.
- Escardibul, J. O., & Mediavilla, M. (2016). El efecto de las TIC en la adquisición de competencias. Un análisis por tipo de centro educativo. revista española de pedagogía, 74 (264), 317-335.
- Escrib Pallarés, F. (1994). *La cúpula y la torre = the dome and the tower*. Sevilla: Fundación Centro de Fomento de Actividades Arquitectónicas.
- Farnos, J. D. (2011). Aprendizaje basado en proyectos con herramientas TIC. *Innovación y conocimiento*. Retrieved from <https://juaandomingofarnos.wordpress.com/2011/03/02/aprendizaje-basado-en-proyectos-con-herramientas-tic/>
- Gómez García, I., Castro-Iemus, N., & Toledo Morales, P. (2015). Las flipped classroom a través del smartphone: efectos de su experimentación en educación física secundaria. *Prisma Social: Revista de Investigación Social*, 15, 296-351.
- González-Barbone, V., & Anido-Rifon, L. (2008). Creating the first SCORM object. *Computers & Education*, 51 (4), 1634-1647. doi: <https://doi.org/10.1016/j.compedu.2008.04.004>
- Guo, P. J., Kim, J., & Rubin, R. (2014). How Video Production Affects Student Engagement: An Empirical Study of MOOC Videos. In *Proceedings of the first ACM conference on Learning* (pp. 41-50). Atlanta: ACM. <https://doi.org/10.1145/2556325.2566239>

- Hall, A. A., & Dufrene, D. D. (2016). Best Practices for Launching a Flipped Classroom. *Business and Professional Communication Quarterly*, 79 (2), 234-242. doi: <https://doi.org/10.1177/2329490615606733>
- Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, 16 (3), 235-266.
- Lonnman, B. (2000). Structural models in design education: Visualising Form and Behaviour. *Architectural Theory Review*, 5 (2), 27-43. doi: <https://doi.org/https://doi.org/10.1080/13264820009478398>
- Mendoza, V. Í. (2015). Flipped Classroom y la adquisición de competencias en la enseñanza universitaria online. *Opción*, 31 (5), 472-479.
- Mok, H. N. (2014). Teaching Tip: The Flipped Classroom. *Journal of Information Systems Education*, 25 (1), 7-11.
- Monedero-Moya, J. J. (1998). *Bases teóricas de la evaluación educativa*. Málaga: Aljibe.
- Ozdamlı, F., & Gulsum, A. (2016). Flipped Classroom Approach. *World Journal on Educational Technology*, 8 (2), 98-105.
- Papazoglakis, P. P. (2013). The Past, Present and Future of SCORM. *Economy Informatics Journal*, 13 (1), 16.
- Pérez-Sánchez, J. C., Piedecausa-García, B., Mateo Vicente, J. M., & Palma Sellés, P. (2015). Elaboración y exposición de maquetas constructivas como metodología docente. In *XIII Jornadas de Redes de Investigación en Docencia Universitaria: Nuevas estrategias organizativas y metodológicas en la formación universitaria para responder a la necesidad de adaptación y cambio* (pp. 975-985). Alicante: Instituto de Ciencias de la Educación.
- Pérez-Sánchez, J. C., Piedecausa-García, B., Pérez Sánchez, V. R., Mora García, R. T., & Céspedes López, M. F. (2016). Herramientas online de interacción docente en las asignaturas Construcción de Estructuras I y II. In *XIV Jornadas de Redes de Investigación en Docencia Universitaria: Investigación, innovación y enseñanza universitaria: enfoques pluridisciplinares* (pp. 1521-1532). Alicante: Instituto de Ciencias de la Educación.
- Pérez Carramiñana, C., Mateo García, M., Maciá Mateu, A., Sirvent Pérez, C. D., Ruiz Cáceres, J. Á., & Piedecausa-García, B. (2010). Proyecto re-Sahara: taller cooperativo entre las asignaturas de Proyectos I, Estructuras II y Construcción III de la titulación de Arquitectura. In M. T. Tortosa Ybáñez, J. D. Álvarez Teruel, & N. Pellín Buades (Eds.), *VIII Jornadas de Redes de Investigación en Docencia Universitaria: nuevas titulaciones y cambio universitario* (pp. 2324-2333). Alicante: Universidad de Alicante.
- Pomares Torres, J. C., Baeza, F. J., Navarro Menargues, M., Castro López, R., Irlés Más, R., García Santos, J. I., & Baeza Cardona, V. (2016). Red de investigación en docencia de cálculo de estructuras I en el grado de arquitectura técnica. In *Investigación e Innovación Educativa en Docencia Universitaria. Retos, Propuestas y Acciones* (pp. 1880-1896). Alicante: Universidad de Alicante, Vicerrectorado de Calidad e Innovación Educativa, Instituto de Ciencias de la Educación (ICE).
- Ruiz-Jaramillo, J., Mascort-Albea, E., & Vargas-Yáñez, A. (2015). Analogue-digital teaching: application of new technologies to learning and continuous evaluation in technical subjects in engineering and architecture higher education. In L. Gómez Chova, A. López Martínez, & I. Candel Torres (Eds.), *8th International Conference of Education, Research and Innovation (ICERI 2015)* (pp. 7050-7056). Sevilla: IATED Academy.
- Salinas, J. (2004). Innovación docente y uso de las TIC en la enseñanza universitaria. *Revista Universidad y Sociedad Del Conocimiento*, 1 (1).
- Schmidt, R. (1983). Interaction, acculturation, and the acquisition of communicative competence. In N. Wolfson & E. Judd (Eds.), *Sociolinguis-*

- tics and language acquisition* (pp. 137-174). Rowley: Newbury House.
- Schmidt, S. M. P., & Ralph, D. L. (2016). The Flipped Classroom: A Twist On Teaching. *Contemporary Issues in Education Research - First Quarter*, 9 (1).
- Stuart, J., & Rutherford, R. J. D. (1978). Medical student concentration during lectures. *The Lancet*, 312 (8088), 514-516. doi: [https://doi.org/10.1016/S0140-6736\(78\)92233-X](https://doi.org/10.1016/S0140-6736(78)92233-X)
- Tawfik, A. A., & Lilly, C. (2015). Using a Flipped Classroom Approach to Support Problem-Based Learning. *Technology, Knowledge and Learning*, 20 (3), 299-315. doi: <https://doi.org/10.1007/s10758-015-9262-8>
- Tejedor Tejedor, F. J., & García-Valcárcel Muñoz-Repiso, A. (2006). Competencias de los profesores para el uso de las TIC en la enseñanza. análisis de sus conocimientos y actitudes. *revista española de pedagogía*, 64 (233), 21-43.
- Uzunboylu, H. (2015). Flipped classroom: a review of recent literature. *World Journal on Educational Technology*, 7 (2), 142.
- Vélez Flores, M. A. (2015). *Impacto de las tecnologías de información en la docencia en la Educación Superior*. León: Universidad de León.
- Wasserman, N. H., Quint, C., Norris, S. A., & Carr, T. (2017). Exploring flipped classroom instruction in Calculus III. *International Journal of Science and Mathematical Education*, 15 (3), 545-568.
- Wilson, K., & Korn, J. H. (2007). Attention During Lectures: Beyond Ten Minutes. *Teaching of Psychology*, 34 (2), 85-89.

Authors' biographies

Jonathan Ruiz-Jaramillo is a PhD in Architecture from the Universidad de Sevilla (2012). Masters in Assessing and Repairing Buildings from the University of Seville. Assistant Professor in the Department of Art and Architecture of the Universidad de Málaga.

Antonio Vargas-Yáñez is a PhD in Architecture from the Universidad de Sevilla (2014). Master's in Environment and Bioclimatic Architecture from the Universidad Politécnica de Madrid. Lecturer in the Department of Art and Architecture of the Universidad de Málaga.