International Journal of Engineering Education Vol. 34, No. 4, pp. 1150–1158, 2018
Printed in Great Britain

0949-149X/91 $3.00+0.00

A Proposed Methodology to Evaluate Educational Competences in Engineering Degrees Based on Electronic Devices and Open Access Software*

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In the new context of the European Higher Education Framework (Bologna Process), the lecturers must cope with the educational achievement assessment and with an appropriate control of the educational process. In this paper, we present the methodology used in the University of Extremadura to evaluate the educational competences in the real time by means of Socrative (by Mastery Connect) launched in smartphones, tablets, laptops, etc. This study has been carried out with the students of two Faculties: the School of Industrial Engineering and the University Centre of Merida, in the framework of an educational innovation project focused on several technical subjects for the mechanical engineering and industrial design degrees. The result shows that the students have improved their competences and their skills, and also the interest in the core syllabus contents, and a great satisfaction with the introduction of this type of activities as a complement to the lectures. Finally, they value this educational experience by means of a surveying, obtaining marks between 83%–85% of the students that consider it as a ''positive'' or ''very positive'' experience. The conclusions of this study show that with the use of this tool (Socrative), the students are more motivated and interested in the content of the subjects, with an improvement of their collaborative attitude in the class. It leads to obtain an outstanding performance, with a failure rate that in our case, has been reduced by a 20% from ''classical'' methodology. In contrast, the implementation of this new technological tool demands a notable effort from lecturers' coordination, besides a supplementary work.

Keywords: e-learning; educational competences; open access software; online surveying; outstanding achievement

1. Introduction

The development of Information and Communication Technologies (ICT) grows continuously bearing aspects that previously corresponded to face-to-face learning. The use of development technology in the classroom enhances learning and this, in turn, may be rendered efficiently with online resources.

In recent decades, technological development has contributed to different electronic devices appearing on the market (smartphones, tablets, ultrabooks...) which, in addition to providing a permanent Internet connection, they stimulate participation and the interest of students in all stages of education. Likewise, and as emphasised by Sevillano and Vázquez-Cano [1], the fact that mobile devices like smartphones actually belong to the users and are on hand twenty-four hours a day, favours the adaptation and access to contents based on the individual needs and competences. Therefore, by introducing mobile devices, like the smartphone, in the teaching-learning-assessment process, an array of multiple education potentials that must necessarily be considered open up [2–5]. Two aspects that can be improved in university teaching is optimising class time and increasing student motivation [6]. Several projects working in this line have demonstrated that mobile technologies can simplify assessments by providing lecturers and students with more immediate progress indicators [1]. In the context of the current Higher Education panorama, students are the main protagonists, and they play an active and participatory role in their own learning process [7]. Therefore, formative assessments have become an ideal system that favour the improvement of the teaching-learning-assessment process, guiding and giving feedback to students so that they can reflect and undertake the precise actions that will allow them to optimise their learning [8]. In this respect, mobile technologies, thanks to their interactive nature, provide an instant response to students about their limitations and strengths, at the same time as they

* Accepted 1 February 2018.

increase the effectiveness of lecturers by automating the distribution and collection of assessments [1].

In this way, the development of educational applications for smartphones and other mobile devices are in constant growth due to the demand generated by users [9], and many are the mobile applications found on the market that facilitate flexibility, communication, access to information and the capacity to create and assess contents by students and lecturers alike. Some examples are Socrative, Flashcards, Kahoot, Blackboard, Moodle and Busuu, among others. A proper use of these types of applications makes them very useful methodological tools for this purpose, complementing the traditional slide presentations in classes and conferences or lectures [10].

There is room for improvement in the effectiveness of lectures as a means of teaching; since, among other things, they promote passivity and loss of concentration on the part of the student after some time [11]. Lecturers who wish to overcome these drawbacks should attempt to increase the level of student participation during class, thus preventing a loss of concentration during long sessions. Cooperative learning and active participation by the students during the development of the class encourages greater motivation, an increase of information retention, better attitudes and an improvement of skills related to critical thinking [12].

This paper pursues two objectives: the first, which, by using this educational methodology, intends to assess specific competences, related to the knowledge and skills relevant to each qualification, and the key competence ''learning to learn'' (EU Reference Framework) in a group of subjects belonging to two different Degree/Study Programmes; and the second, is ascertaining to what extent does the proposed methodology influence the results obtained compared to before, when traditional methods were being used. The educational sphere in which real-time assessment of competences (online) [13–15] is carried out is in the technical subjects of two degrees taught in two Campuses of the University of Extremadura (Uex): the Industrial Design and Product Development Degree (GDIDP) taught at the University Centre of Merida (CUM) and the Mechanical Engineering Degree (GIM) at the School of Industrial Engineering of Badajoz (EEI); with the use of ICT (smartphones, tablets, etc.) and the Socrative mobile application [16, 17].

2. Methodology

Learning competences entail renewing educational effort from the different areas and for the diversity of knowledge fields. This means adapting existing methodologies, applying new resources and instrumental strategies, and even the preparation of new teaching-learning models that focus on cross-sectional content and student training towards their personal and professional maturity. In the light of this, two essential aspects to consider are the need to obtain feedback and to assess results.

From the social moderation perspective, quality is based on the development of a common understanding of the standards [18]. Other researchers [19] affirm that the lecturer needs to understand the student's ideas and encourage them to express and present them. It is also necessary to listen to students, interpret what they say and do, and attempt to understand their conceptual constructs. The lecturer must, therefore, be capable of controlling reconstruction and development and students, on their part, need to be aware of the standards and how to act at the required levels.

In this situation, we have the possibility of making progress in two different strategies. On the one hand, by creating specific models to obtain information and make direct assessments of the results, taking into account the student's progress, and applied for a certain subject, like the haptic models used in the industrial design [20]. And on the other, by establishing current methodologies and tools adaptable to one or more topics, which permit making specific progress in subjects, like the interconnection in global learning, and where lecturers with different profiles may participate and use technological tools [21].

Faced with the need to address and assess specific and transversal competences (related to both attitudes and values—know how to be—and to procedures—know how—), the team of researchers and university lecturers from the University of Extremadura (Uex) determined that immediate data could be obtained on the comprehension and follow-up of a topic through technological resources and encouraging the necessary feedback. Furthermore, this evidence could also be used to address and assess other educational values, like specific and transversal competences. Two cases of analysis were, therefore, presented: the attention towards competences through the real-time follow-up of students' individual responses, which could reveal the degree of motivation and interest, and the comparative study of students' learning process, addressing the key competence for ''learning to learn'' as opposed to prior teaching dynamics in the subjects used in this research. By using tools that permit understanding the necessary process for comprehension and learning, we addressed the essential knowledge, skills and attitudes related to the mentioned transversal (key) competence which could activate the necessary metacognition for the

Table 1. Subjects object of study

Name	Degree	Campus	Type of temporary nature	Type (theoretical/ practical/both)
Manufacturing Processes I	GDIDP	Merida	1st Term	Theory
Technical Office	GDIDP	Merida	1st Term	Practical
Processes and Technology	GDIDP	Merida	2nd Term	Both
Manufacturing Processes I	GIM	Badajoz	2nd Term	Theory

"learning to learn" action [22], that basically means gaining, processing and assimilating new knowledge and skills as well as seeking and making use of guidance. Although, previously it is necessary the acquisition of the fundamental basic skills (like basic skills in ICT used in this research), that provide the assimilation of new knowledge and skills. Below is a description of the methodological progress of the experiment carried out.

2.1 Background

In the academic years 2012–2013 and 2014–2015, the professors of the Engineering of Manufacturing Processes department began a Research Project based on virtual spaces, in online work methodologies with students and new technologies (ICT). The project was a success and a very valid innovative educational action for the students of both centres. This action permitted establishing a link between material (laboratories) and personal resources, which has led to the students knowing the means available in the area of the University of Extremadura. In this project, students were informed of the functionalities and features of each of the pieces of equipment with the purpose of enhancing their theoretical knowledge.

Students assessed the project very positively and recommended continuing with this line of work. The results and resulting documentation were gathered in a publication entitled "Prácticas virtuales de control numérico en laboratorio de Ingeniería de Procesos" [Virtual Practices of numerical control in an Engineering Processes Laboratory] [23].

As mentioned above, this research work represents a continuation of the work produced during the year 2014–2015, which verified that online lecturer-student communication tools are valid instruments to assess knowledge acquired in class.

In this research, we have wanted to make progress and take a step forward in this line of thought, making the most of the possibilities offered by ICT. So, this work team set out to assess the competences acquired by students in the different subjects of a qualification.

2.2 Experiment design

The implementation and analysis of the methodology were carried out in the following phases:

(1) Selection of subjects

As specified in the introduction, the subjects chosen for this paper were of the "technical" type belonging to two different university degrees taught at two different Campus of the University of Extremadura (Table 1). With this election, we intended to ensure the randomness of the sample, which would permit generalising the results obtained.

(2) Work with online communication tool

In this phase, the lecturer prepared a multiple-choice questionnaire to assess the contents explained after class. This questionnaire was presented (controlled by the lecturer in the class) to the students via the Socrative platform, who had online access to the contents on their laptops. After completing the questionnaires, the platform itself provided the lecturers and the students the results of each assessment, presenting both the correct and incorrect answers. This way, students could see both their weaknesses and strengths in the general syllabus of the subject being assessed and even in each topic studied or activity carried out.

(3) Analysis of the data obtained

After having completed the questionnaires, all the data was automatically registered in a database for its subsequent statistical analysis. The tool provides basic graphs and some statistical values by default; but, in our case, we intended to conduct a more complex analysis, an analysis that highlights the benefits of using this tool, as well as the detection of any possible lines for improvement.

In the Spanish system, the marks are directly linked to the results obtained in one or several assessment tests. The student' performance is assessed using a 10-point grade scale, that can be expressed in words as follow (in bold type the estimated ECTS grade equivalence):

"Suspenso" (Failed): 0-4.9 (**FX-F**), "Aprobado" (Pass): 5-6.9 (**C, D or E**), "Notable" (Good): 7-8.9 (**B**), "Sobresaliente" (Outstanding): 9-10 (**A**) and "Matrícula de Honor": Sobresaliente with a special distinction ($\mathbf{A^+}$).

The first analysis consisted of determining the percentages of students that achieved the different marks in two academic years (separately): the year

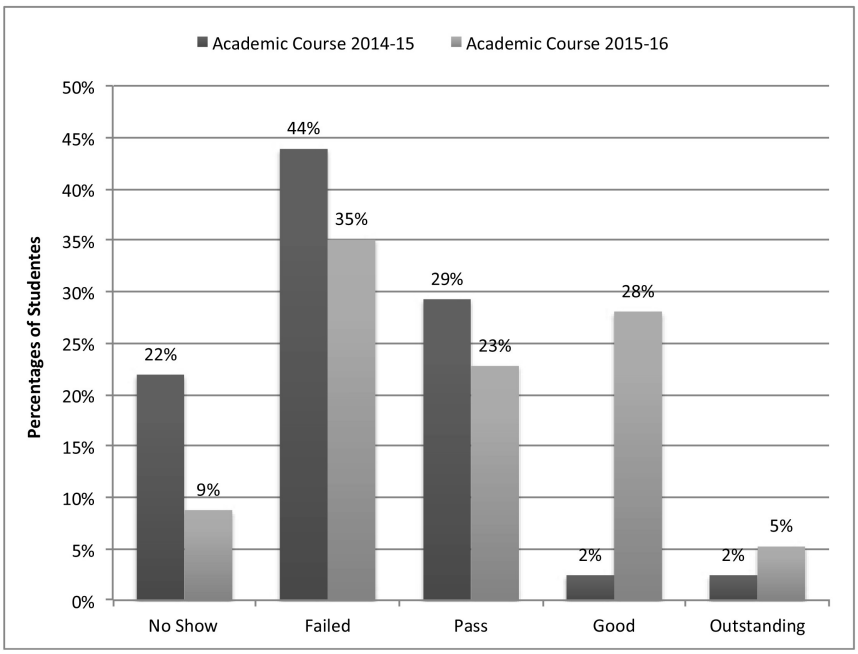

Fig. 1. (a) Marks obtained in Industrial Design and Product Development Degree year 2014–15 with the conventional methodology and (b) Marks obtained in the Industrial Design and Product Development Degree year 2015–16 with the new proposed methodology.

2013–2014 and the year 2015–2016, the latter being in which this new methodology is applied (Fig. 1).

Then, we compared the values obtained in both academic years simultaneously, verifying the influence of this new methodology in the results (Fig. 2).

While the former results show that the use of the new methodology produces improvements in the academic performance of the students, an issue to be resolved is to assess the versatility of the new methodology as far as its employment in ''Theoretical'' or ''Practice'' subjects is concerned.

In order to perform statistical analysis, the ANOVA test was used to determine if populations have the same mean value or not. For this, we used the data obtained during the years 2014–15 and 2015–16 in two subjects that adjust to these two typologies, respectively: Manufacturing Processes I (2nd Term of the GDIDP) and Technical Office (2nd Term of GDIDP). The results are shown in Table 2 and 3.

The results obtained using one-way ANOVA, are shown in Table 4 for the subject Manufacturing Processes I. The ''F'' value of the sample (the academic year 2015–16 and the academic year 2016–17) is 8.77 and higher than the critical F, which is 3.96; p-value = 0 ($p<0.005$). So, we rejected the null hypothesis of equality of means, and we can assure that there is a difference between groups. In

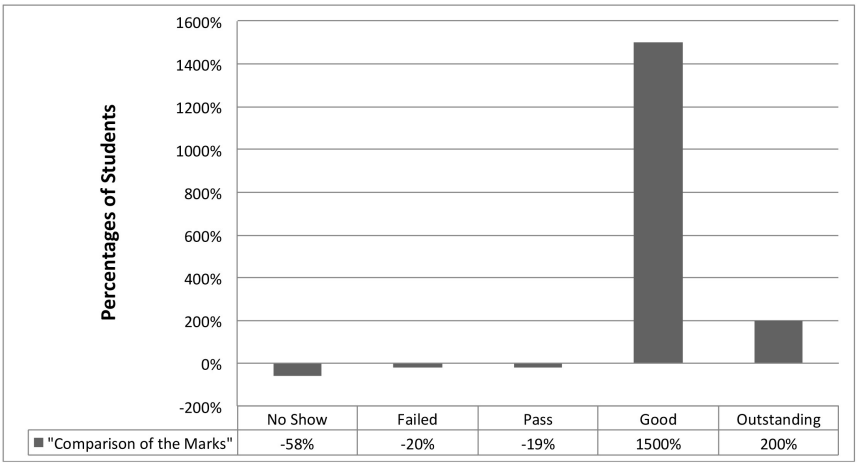

Fig. 2. Comparison of the marks of the year 2015–2016 compared to the year 2014–2015 in the Industrial Design and Product Development Degree.

Table 2. Descriptive statistics from the data experiment for the subject Manufacturing Processes I

Subject MP I	Sample size	Mean	Standard deviation	SE of the mean
Academic year 14–15	32	4.58	1.39	0.24
Academic year 15–16	52	5.71	1.88	0.26

Table 3. Descriptive statistics from the data experiment for the subject Technical Office

Subject TO	Sample size	Mean	Standard deviation	SE of the mean
Academic year 14–15	24	4.72	2.23	0.46
Academic year 15–16	30	5.36	1.96	0.36

Table 4. ANOVA results for a 0.05 level of significance

Origin of variation	DF	Sum of squares	Mean square	F-value	Prob>F	F critical
Model	1	25.6	25.6	8.77	0	3.96
Error	82	239.36	2.92			
Total	83	264.96				

Table 5. ANOVA results for a 0.05 level of significance

Origin of variation	DF	Sum of squares	Mean square	F-value	Prob>F	F critical
Model	1	5.45	5.45	1.25	0.27	4.03
Error	52	226.28	4.35			
Total	53	231.73				

other words, it is evident that the use of the new methodology in the academic year 2015–16 produces different (and better) results to those obtained in academic the year 2014–15.

However, in the case of the Technical Office subject (Table 5), the "F" value is 1.25, and it is not higher than the critical value of the F (4.03), so we cannot say that there is a significant difference between the groups, which demonstrates that, in this case, the use of the new methodology is not a decisive factor to obtain different results.

(4) Student satisfaction survey

With the purpose of knowing students' opinions on the use of the proposed methodology, we prepared an online survey using a form on Google (Google Docs) structured into four blocks:

(a) Block 1, where students state the University Campus in which they are studying, either Badajoz or Merida.
(b) Block 2, with two questions of a general nature. We asked about the suitability of these types of initiatives and on the student's prior experience in similar projects.
(c) Block 3, consists of a set of more specific questions on the proposed methodology, regarding improvement in the comprehension and degree of learning of the subject taught, application times, handling the user interface, etc.
(d) Block 4, asks about the overall assessment of the project directly.

The latest section contains open-ended questions, requesting the students to provide any additional information and suggestions that they may wish to include in the implementation of this methodology.

3. Results and discussion

The results obtained in the 2014–15 and 2015–16 courses cannot be compared directly. This is because, in the 2014–15 course, Socrative was not used. Therefore, and regarding the results of the 2015–16 course, we can affirm that the use of Socrative improves students' learning outcomes. These results of this research show that Socrative is perceived as a good tool to support the teaching-learning process

Below are the results obtained in the survey carried out by 72 of the students that participated in this research, representing 87.80% of the students enrolled in the subjects analysed in this paper. The students spend an average time of 30 minutes to read and filling out the questionnaire (10 minutes and 20 minutes respectively). The data are summarized in Table 6.

In the Block 1, the students stated the University Campus in which they are studying: Badajoz or Mérida. In the Block 2, there are two questions of a general nature, one of them is about the suitability of these types of initiatives and the other is about

students' prior experience in similar projects. We must highlight that 97.2% of respondents considered the project to be innovative and 66.7% had never attended a class like this before. The Block 3, consists of a set of more specific questions on the proposed methodology, regarding improvement in the comprehension and degree of learning of the subject taught, application times, handling the user interface, etc. Finally, the Block 4, asks about the overall assessment of the project directly. In the latest part of the survey, the students explain the proposals that they believe would contribute to improving the implementation of this methodology. Different proposals are contained in this part, like the integration of the methodology in the assessment system, its use in other subjects, increase its use, etc.

The results obtained evidence that the students have been more aware of their own learning (a). In general terms, it attained more interest from the students due to the contents and when facing and solving the activities and tasks set during the development of the subjects. As a consequence of this, we observed a clear improvement of the academic marks that have an impact, above all, on a higher percentage of students achieving the mark of "Good" and a reduction of "Failed" and students with a "No Show" (see Fig. 2). These data show that, from their own capacities, the students have achieved a real improvement in the management of

Table 6. Course feedback by students

	Academic Year 2015/16	
Survey Results	**Nº of responses**	**% of responses**
Block1. Number of participants and University campus of origin		
Badajoz	14	19.4
Mérida	58	80.8
Block 2. Questions of a general nature		
Suitability of these types of initiatives		
(Yes/No)	70/2	97.2/2.8
Prior experience in similar projects		
(Yes/No)	24/48	33.3/66.7
Block 3. Specific questions on the proposed methodology		
Scored from 1point (Highly negative) to 5 points (Highly positive)		
Educational experience obtained with this type of technological tools		
Highly negative	1	1
Negative	4	6
Neutral	15	21
Positive	37	51
Highly positive	15	21
The use of this methodology has improved the comprehension and the learning degree of the subjects		
Highly negative	2	3
Negative	5	7
Neutral	23	32
Positive	24	33
Highly positive	18	25
With this methodology, the classes turn out to be more pleasant and satisfactory		
Highly negative	1	1
Negative	0	0
Neutral	5	7
Positive	27	38
Highly positive	38	54
The use of the interface is intuitive and easy		
Highly negative	0	0
Negative	1	1
Neutral	5	7
Positive	18	25
Highly positive	48	67
Block 4. Global evaluation of the project		
Scored from 1 point (Highly negative) to 5 points (Highly positive)	**Nº of responses**	**% of responses**
Highly negative	0	0
Negative	1	1
Neutral	11	15
Positive	41	57
Highly positive	19	26

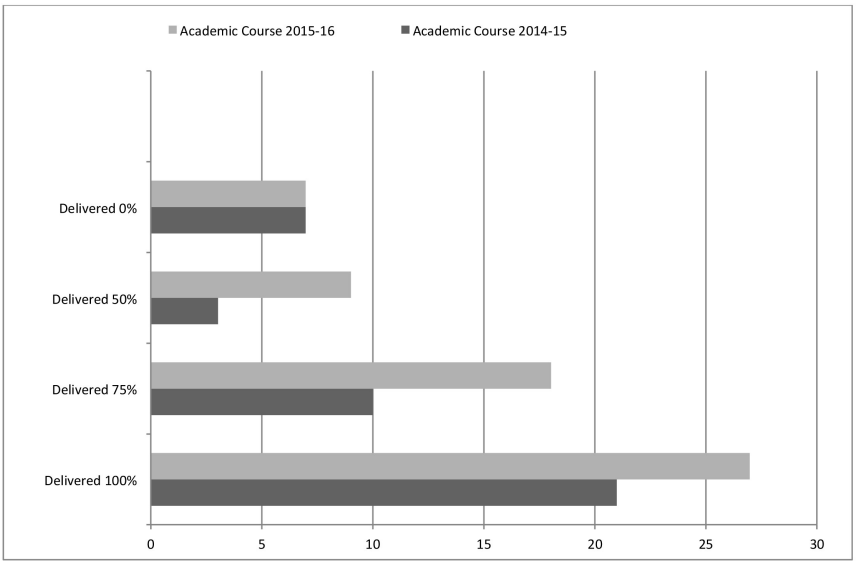

Fig. 3. Comparison of papers for the practical subjects in the courses analysed.

their knowledge (b). Finally, we have also been able to verify that the pleasantness of this type of training exceeds traditional lectures and permits the interrelation lecturer-student, as we can see in Fig. 3, that shows the increase in the delivery of papers for the practical subjects by students in the subject Manufacturing Processes I compared to the previous year. These general results stress the importance of the use of new technological resources in the intellectual work, providing more clear-sightedness to the knowledge (c), and therefore, highlight the TIC's importance as an instrumental resource. These (a), (b) and (c) evidences are, in fact, the main descriptors of the transversal (key) competence for "learning to learn" explained in the second point (Methodology) of this paper.

Moreover, as regards the suitability of the proposed methodology, the ANOVA statistical analyses demonstrate that this is the most appropriate methodology for "Theoretical" subjects and not so much for the "Practical" ones.

Likewise, the results of the satisfaction survey reveal that a high percentage of students are satisfied with the implementation of this methodology and, as Johnson, Johnson, & Smith [24] said, they valued their educational experience positively.

4. Conclusions

With regard to the benefits and difficulties of introducing this new methodology in the teaching-learning-assessment process, it is noted that lecturers and students alike consider that there are many benefits and minimum difficulties. It is worth noting that these methodologies, while they have resulted in an improvement of the results and the teaching-learning process, they demand a considerable coordination effort by lecturers. This determines the value of the discussion and consensus of the teaching activity, for the revision of the necessary knowledge acquired in the learning processes of the topics grouped as a set of subjects of the same university degree.

In the light of the results obtained, it is worth noting that, in addition to a greater attendance to the theoretical and practical sessions, higher marks were obtained and a lesser number of No Shows (58%), that is, student abandonment rate dropped. The generalised improvement of the final marks of the subject is also worth highlighting, with a 20% drop in "Failed".

With the tracking (by the lecturer) of the learning process evolution and its results, the student can also understand which standards are required to "learning to learn". This conclusion is reached as a result of the high valuation expressed by the students compared to the comprehension of the subject, described in block 3, and which entails an improvement in the learning results indicated by the ANOVA results. This observation allows concluding that students can develop metacognition resources necessary to meet the above standards.

At this stage of the conclusions, we believe that a manner of addressing the key competence for "learning to learn" had indeed been activated, because the following descriptors are met: the awareness of the necessary knowledge, motivation and the suitability in the management and control of personal abilities, and the use of resources and techniques.

From this last conclusion, we believe that question typologies and frameworks that could activate

different skills according to the content profile and subject, and thus address other competences, such as ''the capacity of analysis or synthesis'' need to be established.

Acknowledgments—The study formed part of the Innovation Project (SOFD) developed during the academic years 2015 and 2016. Also, the authors wish to express their gratitude to the Regional Government in Extremadura, for the vast information provided during the course of the present work, which was supported by Project GR-15057 from the Regional Government of Extremadura and the European ESIF funds.

References

1. M. L. Sevillano and E. Vázquez Cano, *Modelos de investigación en contextos ubicuos y móviles en Educación Superior*, McGraw-Hill, Madrid, 2015.
2. J. Trinder, Mobile Technologies and systems, in A. Kukulska-Hulme & J. Traxler (eds), *Mobile Learning: A Handbook for Educators and Trainers*, new edn, Routledge, London, 2005, pp. 7–25.
3. F. Brazuelo and D. J. Gallego, *Mobile Learning. Los dispositivos móviles como recurso educativo*, MAD, Sevilla, 2011.
4. E. Sandoval, R. García and M. Ramírez, Competencias tecnológicas y de contenido necesarias para capacitar en la producción de recursos de aprendizaje móvil, *EDUTEC, Revista Electrónica de Tecnología Educativa*, **39**, 2012, pp. 1–16.
5. F. Navaridas, R. Santiago and J. Tourón, Valoraciones del profesorado del área de Fresno (California central) sobre la influencia de la tecnología móvil en el aprendizaje de sus estudiantes, *Relieve*, **19**(2), 2013, pp. 1–19.
6. A. Kukulska-Hulme and J. Traxler, *Mobile Learning. A handbook for educators and trainers*, Routledge, London, 2005.
7. J. Espinosa, J. Jiménez, M. Olabe and X. Basogain, Innovación docente para el desarrollo de competencias en el EEES. *Proceedings of the VII Congreso de Tecnologías Aplicadas a la Enseñanza de la Electrónica*, Madrid, Spain, 2006, pp. 1–5.
8. R. Romero-Martín, F. J. Castejón-Oliva and V. López-Pastor, Divergencias del alumnado y del profesorado universitario sobre las dificultades para aplicar la evaluación formativa, *Relieve*, **21**(1), 2015, pp. 1–17.
9. F. Mora, El Mobile Learning y algunos de sus beneficios, *Revista Calidad en la Educación Superior*, **4**(1), 2013, pp. 47–67.
10. P. Wash and G. Freeman, BYOD—Engaging Students Using Their Own Devices, *National Social Science Technology Journal*, **2**(1), 2013.
11. K. Miller, Socrative, *The Charleston Advisor*, **15**(4), 2014, pp. 42–45.
12. M. Cavanagh, Students' experiences of active engagement through cooperative learning activities in lectures, *Active Learning in Higher Education*, **12**(1), 2011, pp. 23–33.
13. D. F. Cambronero, F. J. Ruiz-Piñar, F. G. Márquez, V. Burillo-Martínez and T. de Miguel Moro, Uso de técnicas de virtualización para mejorar la docencia en laboratorios de redes ce comunicación, *Proceedings of the V Jornadas de Ingeniería Telemática*, Vigo, Spain, 2005, pp. 1–8.
14. J. G. Sanz-Calcedo, D. R. Salgado and I. Cambero, *Proyecto de Innovación, Virtualización de prácticas de laboratorio: una estrategia de e-learning en la docencia universitaria*, Universidad de Extremadura, 2013.
15. J. García Sanz-Calcedo, D. Rodríguez Salgado and I. Cambero, Application of techniques based on reliability for the improvement of the teaching of mechanisms in industrial design, *Mechanisms and machine science*, **19**, 2014, pp. 101–111.
16. L. Canós Darós, M. Canós Darós and V. Liern Carrión, El uso de las nuevas tecnologías aplicadas a la educación superior: XVII Jornadas ASEPUMA—V Encuentro Internacional, *Rect@*, **17**(1), 2009, pp. 1–14.
17. N. González-Fernández and I. Salcines-Talledo, El Smartphone en los procesos de enseñanza aprendizaje-evaluación en Educación Superior. Percepciones de docentes y estudiantes, *Relieve*, **21**(2), 2015, pp. 1–19.
18. G. S. Maxwell, *Moderation of assessments in vocational education and training*, Brisbane: Queensland Department of Employment and Training, 2001.
19. L. E. Adie, V. Klenowski and C. Wyatt-Smith, Towards an understanding of teacher judgement in the context of social moderation, *Educational Review*, **64**(2), 2012, pp. 223–240.
20. C. Cruz, Idear la forma: Capacitación creativa, *Cuadernos de Estudio del Centro de Estudios en Diseño y Comunicación*, **43**, 2013, pp. 113–125.
21. H. Costea, Engineering education with new enabling technologies, *Proceedings of the* 1997 *IEEE International Conference on Systems, Man, and Cybernetics*, Orlando, USA, 1997, pp. 2063–2068.
22. S. Paris and P. Winograd, How metacognition can promote academic learning and instruction, in B. Jones and L. Idol (eds), *Dimensions of thinking and cognitive*, Hillsdale: Lawrence Erlbaum Associates, New Jersey, USA, 1990, pp. 15–51.
23. A. G. González, J. G. Sanz-Calcedo, Ó. L. Pérez, D. R. Salgado, I. Cambero and J. M. Herrera, *Prácticas virtuales de control numérico en laboratorio de Ingeniería de Procesos*, Federación de Gremios de Editores de España, 2014.
24. D. W. Johnson, R. T. Johnson and K. A. Smith, *Cooperative Learning: Increasing Collage Faculty Instructional Productivity*, The George Washington University, USA, 1991.

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