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ARTICLE

On How Moodle Quizzes Can Contribute to the Formative e-Assessment of First-Year Engineering Students in Mathematics Courses

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Abstract

Given the importance of formative assessment in the context of the European Higher Education Area, it is necessary to explore new tools to implement innovative strategies for the formative assessment of students. Moodle's quiz module represents an alternative to traditional tools, such as paper-and-pencil tests. In 2008, we carried out a project subsidised by the Institute of Education Sciences at the Universitat Politècnica de Catalunya - BarcelonaTech (UPC), the main aim of which was to elaborate a number of Moodle question pools and to design, implement and assess a series of quizzes from these pools. The project covered the compulsory undergraduate subjects in applied mathematics included in the first- and second-year syllabuses for all branches of Engineering. From the students' results, it was then necessary to examine and revise the reliability of the quizzes as an assessment tool of the teaching and learning process. The analysis of the psychometric coefficients provided by Moodle proved to be a useful tool for assessing whether the questions had an appropriate level of difficulty and were suitable for discriminating between good and bad performers. Taking into account the psychometric analysis of this first project, in 2009 we initiated a new project, in which we planned to revise thoroughly the quizzes created in the former project, to improve their suitability as an assessment tool. This paper shows: i) the students' results in the quizzes performed in the two academic years in the courses Mathematics 1 and Mathematics 2 – both taught in the first year of the four bachelor's degree programmes in Biological Systems Engineering organised by the School of Agricultural Engineering of Barcelona at the UPC, as well as the students' attitudes towards activities of this kind; and ii) the revision and fine-tuning of the quizzes from the psychometric analysis to improve their reliability. Finally, the analysis of the results reported leads to a discussion on the advisability of using this tool for the formative assessment of students.

Keywords

mathematics, quizzes, Moodle, assessment, psychometric analysis

Los cuestionarios del entorno Moodle: su contribución a la evaluación virtual formativa de los alumnos de matemáticas de primer año de las titulaciones de Ingeniería

Resumen

En el contexto del Espacio Europeo de Educación Superior, en el que la evaluación formativa desempeña un papel esencial, es necesario explorar nuevas herramientas con el fin de implementar estrategias innovadoras de seguimiento y evaluación de los estudiantes. El módulo de cuestionarios en el entorno Moodle representa una alternativa frente a las metodologías tradicionales, como pueden ser las pruebas escritas. En el marco de las ayudas para la mejora de la docencia concedidas por el Instituto de Ciencias de la Educación de la Universidad Politècnica de Catalunya - BarcelonaTech (UPC), durante el curso académico 2008/2009 se llevó a cabo un proyecto docente cuyo objetivo principal era el diseño de preguntas tipo test y su posterior implementación en cuestionarios del entorno Moodle para asignaturas de matemáticas y estadística correspondientes a primeros cursos de titulaciones de ingeniería. Con los resultados de los cuestionarios realizados por los estudiantes, se vio que era conveniente analizar y revisar su fiabilidad y adecuación para avalar estas actividades de evaluación del proceso de aprendizaje. El análisis de los coeficientes psicométricos facilitados por Moodle resultó ser una herramienta útil a la hora de valorar si las cuestiones propuestas tenían el nivel de dificultad adecuado y si, en consecuencia, eran convenientes para discriminar entre buenas y malas prácticas. En el marco de otro proyecto, también subvencionado por la UPC, durante el siguiente curso académico 2009/2010 se revisaron de forma exhaustiva los cuestionarios implementados con el fin de mejorar su eficiencia como herramienta de evaluación. En este trabajo se presentan: i) los resultados de los cuestionarios realizados por los estudiantes durante esos dos cursos académicos en las

asignaturas Matemáticas 1 y Matemáticas 2 de primer año de los cuatro grados de Ingeniería de Biosistemas de la Escuela Superior de Agricultura de Barcelona de la UPC, así como la opinión de los estudiantes sobre este tipo de actividad, ii) la revisión y adaptación de los cuestionarios a partir de los índices psicométricos para mejorar su eficiencia. Finalmente, a partir de los resultados analizados se hace una reflexión sobre la conveniencia de utilizar este tipo de herramientas para la evaluación formativa de los estudiantes.

Palabras clave

matemáticas, cuestionarios, Moodle, evaluación, análisis psicométrico

1. Introduction

The Bologna Declaration and the implementation in 2010 of the European Higher Education Area (EHEA) brought about crucial changes both in the curriculum and in teaching-learning methodologies in university studies (ENQA, 2005). The EHEA promotes a student-centred system based on the student workload required to achieve the objectives of a programme of study. These objectives should be articulated in terms of learning outcomes to be acquired. Learning outcomes are sets of competencies, expressing what the student will know, understand or be able to do after completion of a process of learning. Competencies represent a dynamic combination of attributes, abilities and attitudes, which should correspond to specified learning outcomes. In this framework, student workload consists of the time required to complete all planned learning activities such as attending lectures, seminars, independent and private study, project preparation and examinations. The assessment of students is a cornerstone of the EHEA and is expected to “measure the achievement of the intended learning outcomes and other programme objectives” (ENQA, 2005). ENQA’s guidelines for the assessment of students also include desirable procedures that should be followed in the assessment process.

According to the EHEA guidelines, it is clear that formative practices are a central component in the assessment of students. Among the aspects that lecturers must take into account when designing and developing tools for formative assessment of the teaching-learning process, we would stress the following: i) To reflect on actions before, during and after the learning process, on the part of the lecturer and the learner; ii) To include assessments for both learning outcomes and learning processes; iii) To provide feedback to improve both the teaching and the learning processes; iv) To incorporate student self-assessment and self-regulation procedures; and v) To explain and share evaluation criteria with students.

Furthermore, several studies have pointed out the increasing role of information and communication technologies (ICTs) in the field of assessment (Delgado and Oliver, 2006; Graff, 2004; Steegmann et al., 2008), to the extent that *e-assessment* has emerged as a new issue in the educational arena (Brinck and Lautenbach, 2011; Crews and Curtis, 2011; Daly et al., 2010; Ferrão, 2010). Given the importance of formative assessment in the context of the EHEA, it is fundamental

to explore new evaluation strategies to innovate assessment methods. As Ferrão (2010) points out, the system of e-assessment must have the hardware and software necessary for test generation and administration.

Most Spanish universities have adopted Moodle as a learning management system (LMS) to help educators create quality online courses and administer learner outcomes (Steedmann et al. 2008). Therefore, in this paper we focus on the quiz module provided by Moodle. This module allows for the creation of quizzes with different question types, adapted to the specific objectives to be achieved at any step in the teaching-learning process, supplying prompt, automatic feedback. A powerful tool for monitoring and diagnosing students' learning, Moodle's quiz module represents an alternative to traditional face-to-face courses and paper-based testing. Regarding the quality of the e-assessment system, Moodle's quiz module supplies statistical methods to measure the reliability of the tests (Ferrão, 2010). It has been argued that, in relation to the use of ICTs, the boundaries between formative and summative assessment become blurred (Daly et al., 2010). However, if technologies are used to carry out low-stakes assessment activities on a regular basis, they can contribute to formative assessment. Moodle quizzes not only prove suitable for carrying out such activities, but they can also be modified and adapted according to learners' needs. As discussed in Daly et al. (2010), adaptivity is a key feature of e-assessment, since feedback is used formatively by learners to adapt their conceptions and approaches to a task, and by lecturers to adapt a task to learners' needs. We are well aware that quizzes have become a widely used tool for assessment in recent years (Ferrão, 2010). However, to our knowledge, there is no detailed survey on how to make the most of psychometric coefficients to refine quizzes implemented in undergraduate mathematical courses.

This paper reports on the main outcomes of two educational projects where Moodle quizzes were used as a tool for formative e-assessment in the context of two compulsory undergraduate mathematical courses. The projects aimed:

1. To design a number of quizzes to assess regularly the topics of the two courses, with a subsequent analysis of the learners' results and their correlation with other teaching-learning activities involved in the courses, as well as to collect the students' attitudes towards e-assessment.
2. To carry out a psychometric analysis as a means of feedback on the learning activities in order to adapt them to the learners' needs and therefore to refine and improve their reliability as a tool for formative e-assessment.

2. Material and methods

Since 2009, the School of Agricultural Engineering of Barcelona (ESAB) at the Universitat Politècnica de Catalunya - BarcelonaTech (UPC) has offered the following bachelor's degree qualifications in Biosystems Engineering: Degree in Agricultural Engineering, Degree in Biological Systems Engineering, Degree in Agro-Environmental and Landscape Engineering, and Degree in Food Engineering. The four bachelor's degrees share a set of compulsory subjects in the first and second years, which count as six European Credit Transfer System (ECTS) credits each. Two first-year courses in mathematics,

Mathematics 1 and Mathematics 2, are included in this initial common set. It is worth noting here that the essentially biological profile of the ESAB has arguably contributed to the students' poor motivation in mathematical and statistical areas, and this has traditionally resulted in low pass rates. In order to improve the learning outcomes and to motivate the students, we decided to launch a series of low-stakes tasks as an incentive (Lim et al., 2011). Yet, if we wanted to meet the EHEA guidelines on assessment while dealing with a growing number of students, this would doubtless mean an increase in teaching staff workload. In order to carry out continuous assessment of our students without investing an excessive amount of time marking, it seemed appropriate to resort to the range of e-tools available.

In 2005, the UPC started to use Moodle, an open-source LMS that offers a wide variety of teaching tools (Cole, 2005). In order to make the most of the tools available, we started exploring Moodle's assessment facilities. In 2008/2009, we carried out a project subsidised by the Institute of Education Sciences at the UPC, the main aim of which was to design, elaborate and implement a substantial range of Moodle question pools for quizzes (*"Creació de qüestionaris des de l'entorn Moodle per a assignatures de matemàtiques i estadística corresponents a primers cursos de titulacions d'enginyeria"*). The project covered the compulsory undergraduate subjects in applied mathematics included in the first- and second-year syllabuses for all branches of Engineering. In practice, it was mainly centred on Mathematics 1 (M1) and Mathematics 2 (M2), compulsory for all students enrolled in the ESAB. In this project, we analyzed the students' answers, and carried out a psychometric analysis to identify the appropriateness of the questions asked in the quizzes. It is important to stress that a preliminary experience was carried out with a small group of students the year before the new bachelor's degree system started. This initial experience seemed to suggest that Moodle quizzes were certainly useful for the promotion of student involvement in mathematical subjects.

However, it is essential to bear in mind that the whole process should be permanently revised and updated. Therefore, carrying out an evaluation of the various experiences in Mathematics 1 and Mathematics 2 provided the research group with insights into the entire assessment process.

From those initial experiences, we planned to generate improved quizzes suitable for the mathematics courses mentioned above. The psychometric analysis provided by Moodle was a great tool for assessing whether the questions were suitable for discriminating between good and bad performers, with an appropriate level of difficulty.

Taking account of the psychometric analysis of that first project, in 2009/2010 we carried out a new project in which we planned to revise thoroughly the quizzes created in the former project in order to improve their reliability as an assessment tool (*"Revisió i millora de l'eficiència de qüestionaris MOODLE implementats en assignatures de matemàtiques i estadística corresponents a primers cursos de titulacions d'enginyeria"*).

In order to supervise the students' progress at different stages of the learning process (Heck and Van Gastel, 2006), we created quizzes for different contexts, such as diagnostic and post-performance tests, computer lab sessions and chapter checking after the accomplishment of each unit of content. This contribution focuses on the set of Moodle quizzes that were designed as take-home assignments for chapter checking, to be completed within a given time frame. The topics covered by each of the

quizzes in Mathematics 1 and Mathematics 2 were aligned with the learning goals and required outcomes of the course (Tables 1 and 2). Since different kinds of questions can help to develop different skills (Smith et al., 1996; Blanco et al., 2009), the questions used in these quizzes were of several types: multiple-choice, true/false, short-answer, numerical, matching and embedded (cloze) (Table 3).

Summative assessment in both courses is carried out on the basis of a weighted formula computed as follows: two or three written tests during the semester (45%); a cumulative final written exam (40%); computer lab sessions (5%); quizzes (5%); and several homework and coursework assignments (5%). It is within this framework that the quizzes have to be considered.

Table 1. Topics covered by quizzes in Mathematics 1.

Q1	Q2	Q3	Q4	Q5	Q6
Functions of a real variable	Functions of several real variables	Determinants and Systems of linear equations	Complex numbers	Optimization of functions of a real variable	Optimization of functions of several real variables

Table 2. Topics covered by quizzes in Mathematics 2 (ODEs: Ordinary Differential Equations).

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Basic integration by substitution	Integration by substitution	Integration by parts	Integration by partial fractions	General topics on ODEs	Separable ODEs	Homogeneous ODEs	

Table 3. Number of questions and question types corresponding to the first project (changes made in the second project in brackets).

	Number of questions	Multiple-choice	True/False	Matching	Short-answer/ Numerical	Cloze
M1	83	65 (60)	10 (18)	3	5 (2)	
M2	59	19	38			2

3. Results and discussion

As an interactive and dynamic tool, Moodle quizzes have an impact on the lecturers' and students' attitudes towards computer-assisted assessment. Moreover, the fact that the number of enrolled students has been growing in recent years means that we have to apply the EHEA guidelines (ENQA 2005) to groups of 60 students or more. Hence, the automatic assessment offered by the quizzes can free up time for lecturers to concentrate on other aspects of the learning process (Blanco et al., 2009). As mentioned earlier, the UPC's LMS – Atenea – is based on Moodle. From the very beginning, the university's strategy has been to encourage lecturers and students to use this LMS to work towards

the learning and teaching process as understood by the EHEA. So, the use of Moodle's quiz module, as described in this paper, is a move in that direction. This section is organized as follows. The first subsection analyzes the students' results for the quizzes set in both academic years (2009/2010 and 2010/2011). The second subsection presents the main results for the psychometric analysis of the quizzes. The third and final subsection discusses the students' opinions on the quizzes.

3.1. Analysis of the students' results

In the context of our projects, Moodle's quiz module provided information about which questions our students got wrong or partially right, overall quiz results and individual responses. In both projects, we performed a linear regression analysis relating the score mean of the quizzes to the final mark of Mathematics 1 and Mathematics 2, computed using the above-mentioned weighted formula (Figure 1). Overall, the analysis was significant and displayed a good positive linear correlation, with the following correlation coefficients: 0.69 (p -value <0.001) for M1 in 2009/2010 (with $N_1=91$ students); 0.55 (p -value <0.001) for M2 in 2009/2010 (with $N_2=78$ students); 0.44 (p -value <0.001) for M1 in 2010/2011 (with $N_3=176$ students); and 0.67 (p -value <0.001) for M2 in 2010/2011 (with $N_4=154$ students). These results led us to conclude that Moodle quizzes can be regarded as a suitable tool to inform students of their performance throughout the learning process, in line with Ferrão (2010).

It is interesting to note that, from the data, it is possible to recognize the different strategies that the students use to pass the course. These different behaviours can explain some of the atypical or extreme observations collected over the two years in question. The year 2009/2010 was an exceptional course because there were only new students in the two courses, that is, none of them were retaking the year. In contrast, in the following year, new students and students retaking the course were mixed in the same classroom. The behaviour of the latter was noticeable; their quiz results were different from those of the former (Figure 1). Moreover, it is evident that the results for the Mathematics 2 course were better than those for the Mathematics 1 course, especially in 2009/2010. This is understandable in the following context: i) the nature of the topics of this second subject of mathematics is different from the first one, with new topics for all the students and, in some way, independent from those studied in previous mathematics courses at high school (Tables 1 and 2); ii) the students of Mathematics 2 have already gone through a previous mathematics course and have therefore learnt how to adapt successfully to the environment; and iii) the students who chose to pursue the second subject are the good students from the previous semester (that is to say, they passed Mathematics 1) or, if they were retaking the course, they may have had some advantage over the students taking the subject for the first time. This aspect becomes much more evident in the year 2010/2011, Mathematics 2, as Figure 1 shows. The four scatter plots show a higher concentration of points in the first and third quadrants. When it comes to Mathematics 2 in 2010/2011, it is true that marks are mainly concentrated in the first quadrant only. This means that most of the students who took the quizzes, passed both the quizzes and the course in general, thus providing more evidence supporting the particular nature of Mathematics 2 observed in the second academic year.

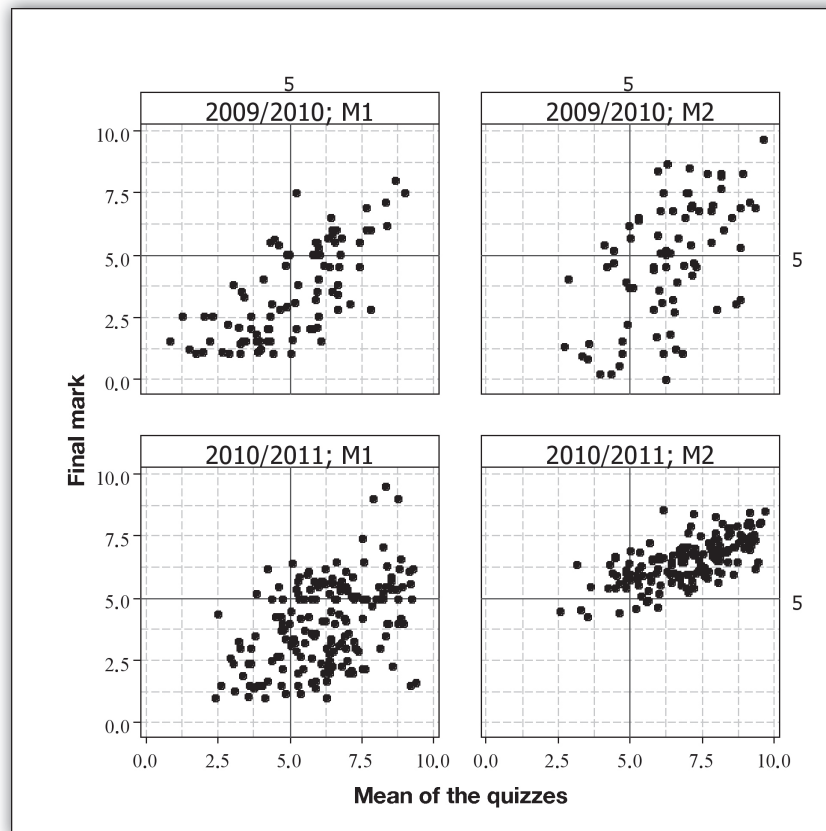


Figure 1. Scatter diagrams of the mean of the students' scores in the quizzes and the final mark in the two subjects (M1: Mathematics 1, and M2: Mathematics 2) in the years 2009/2010 and 2010/2011.

3.2. Psychometric analysis

As Ferrão (2010) argues, the e-assessment system must provide a set of tools to analyze the reliability of the tests and, consequently, to ensure the quality of the system. Psychometric analysis is a great tool for assessing whether the quizzes are a reliable instrument for measuring the students' performance, attitudes and abilities (Heck and Van Gastel, 2006). Moodle's quiz module performs the item analysis of a quiz, a particular tool associated with psychometrics. Having performed the item analysis, the module allows all the statistical reports to be exported as a spreadsheet file, rendering all the information easier to manage.

In this section, we discuss two parameters provided by the item analysis of the quizzes: the Facility Index (FI) and the Discrimination Coefficient (DC). These parameters, calculated as explained by classical test theory, can help us answer whether the questions are well chosen in order to demonstrate concepts and of an appropriate level of difficulty, and whether the questions are suitable enough to discriminate between good and bad performers. The FI describes the overall difficulty of the questions. This index represents the ratio of users that answer a question correctly. In principle, a very high or low FI suggests that a question is not useful as an instrument of measurement. The DC is a correlation coefficient between scores at the item and at the whole quiz level, ranging from -1 to +1. This is another measure of the separating power of the item to distinguish proficient from weak learners.

Although it is necessary to be cautious when relying upon item-discrimination parameters (Burton, 2001), we opted for the DC because it is associated with the Moodle tools available. In addition, since the quizzes did not contain disparate topics, as Tables 1 and 2 show, they met one of the requirements indicated by Burton (2001) for the performance of a more reliable item-discrimination analysis.

At the beginning of the first project, we decided to group the DC values into three categories: Low ($DC < 0.33$), Medium and High ($DC > 0.66$). In order to discard those questions with FI values that were either too low or too high, the boundaries were set at 15 and 85, respectively. Quizzes with just a few questions with FI values between 15 and 85 should be newly constructed, as should those with low DC values. In 2009/2010, we set ourselves the goal of revising and redesigning those quizzes with low DC values or with FI values that were either too low or too high.

When it comes to Mathematics 1, from the information provided by Moodle, only those questions with FI values that were either very low or very high should be rewritten, as should those with low DC values. In Blanco and Ginovart (2010b), there is a detailed description of how the revision of questions was tackled. Once revised, the quizzes were run again and a new psychometric analysis was carried out. Table 4 shows that the results of the psychometric analysis obtained in the second year are generally better than those obtained in the first year. Another way to display the results of the psychometric analysis is to focus on the individual quiz questions, rather than on the quizzes as units. The plots in Figure 2 and Figure 3 seem to indicate an improvement in the psychometric analysis after the revision, with higher DC values in the second year than in the first year.

Table 4. Mathematics 1: Psychometric analysis corresponding to 2009/2010 and 2010/2011.

<i>M1</i>		<i>FI (%)</i>		<i>DC</i>		
		<i>Range</i>	<i>% of questions with FI between 15 and 85</i>	<i>% of questions with Low DC</i>	<i>% of questions with Medium DC</i>	<i>% of questions with High DC</i>
Q1	2009/2010	14-82	93.3	20	80	0
	2010/2011	36-84	100	0	100	0
Q2	2009/2010	32-85	100	13	74	13
	2010/2011	41-91	80	7	80	13
Q3	2009/2010	22-87	94.1	18	76	6
	2010/2011	25-96	64.7	12	82	6
Q4	2009/2010	57-86	90	0	90	10
	2010/2011	23-87	90	20	70	10
Q5	2009/2010	24-73	100	21	50	29
	2010/2011	21-86	92.9	7	86	7
Q6	2009/2010	29-66	100	8	76	16
	2010/2011	18-78	100	8	76	16

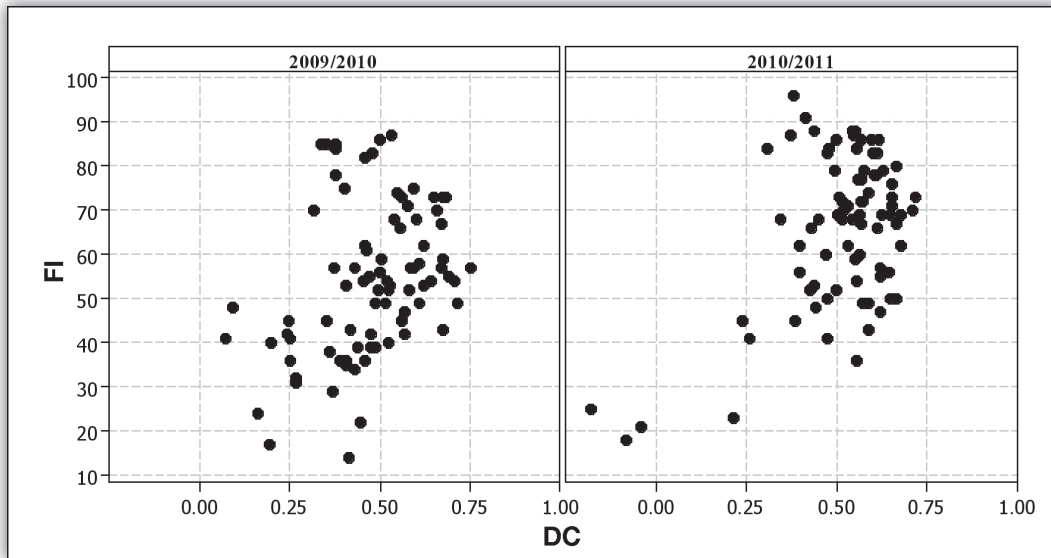


Figure 2. Mathematics 1: Scatter plots of FI and DC, corresponding to all the questions used in the six quizzes in the years 2009/2010 and 2010/2011.

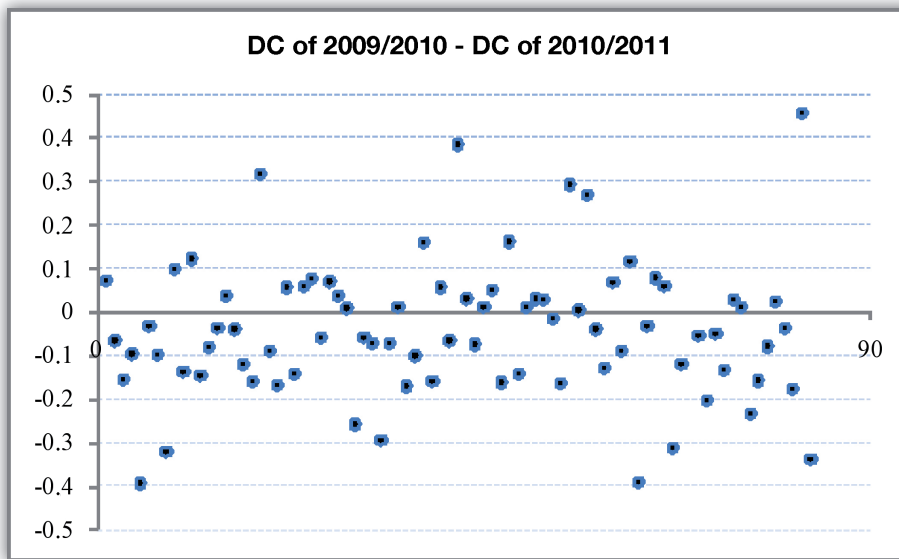


Figure 3. Mathematics 1: Plot of the difference between the DC values in 2009/2010 and in 2010/2011 for each question.

With regard to the eight quizzes performed in Mathematics 2, in the first year (2009/2010), the solutions for the quizzes were made available on the UPC’s virtual teaching campus. There was therefore a risk that this, together with the fact that the quizzes were take-home assignments, might tempt the students to copy the answers from the previous year. Consequently, to prevent the students from cheating, in the second year 2010/2011, we redesigned the quizzes already answered the previous year by introducing a few changes, mainly numerical, enough to maintain the essence and reliability of the quizzes. Nevertheless, this could not be taken for granted, since factors alien to the questions, such as changes in the student cohort or changes in the teaching team, might have an impact on the results of the item analysis of a particular quiz. As Figure 4 suggests, such changes

in the questions, however slight, could lead to different outcomes, depending on the features of the group of students involved. The positive results obtained in the second year, as noted above, are reflected in higher FI values in general. The random distribution of values around zero in Figure 5 aligns with the fact that no specific action was taken to improve the DC of the quiz questions of Mathematics 2, in contrast to Figure 3, where the values tend to concentrate in the area below zero. Notwithstanding the slight changes made to the quizzes, it is possible to assert that they maintained their DC values in the main. This is therefore acceptable in terms of arguing in favour of the DC's reliability as a psychometric parameter in our study.

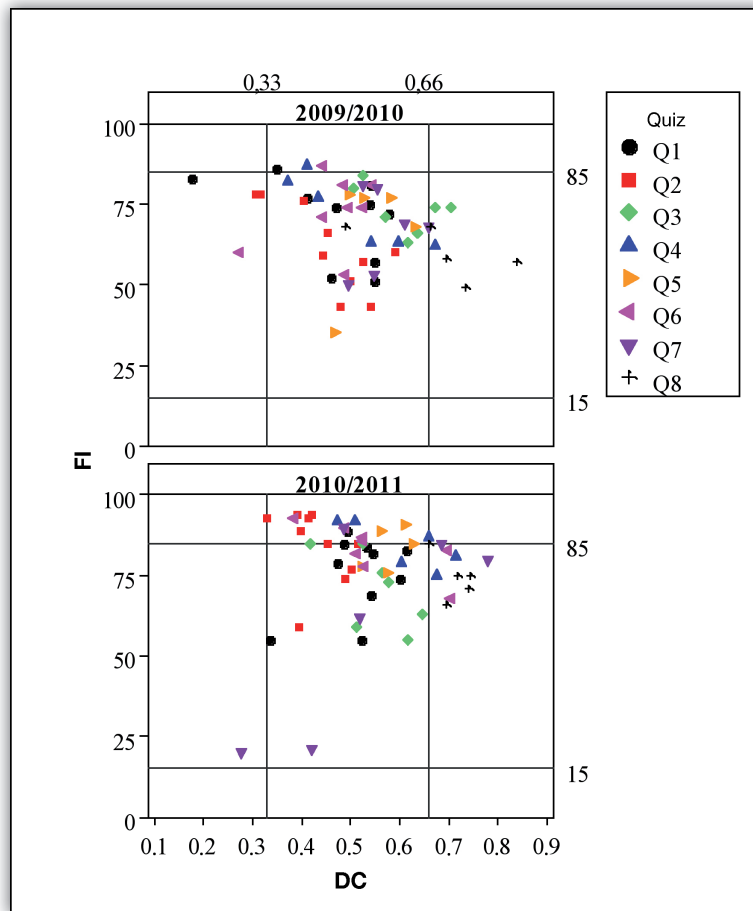


Figure 4. Mathematics 2: Scatter plots of FI and DC, corresponding to all the questions used in the eight quizzes in the years 2009/2010 and 2010/2011.

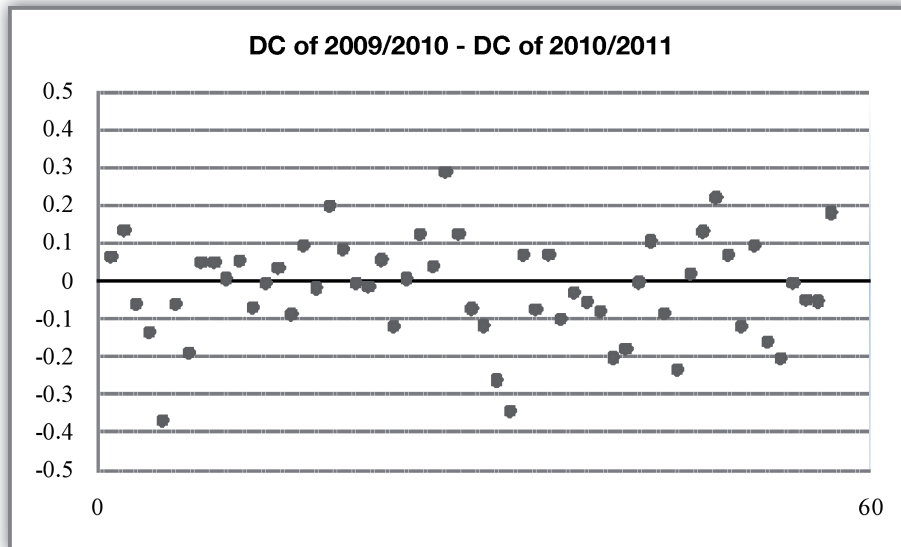


Figure 5. Mathematics 2: Plot of the difference between the DC values in 2009/2010 and in 2010/2011 for each question.

3.3. Analysis of the students' ratings of Moodle quizzes

Some years before the creation of the four bachelor's degree courses in Biosystems Engineering at the UPC, the teaching and learning of mathematical topics at the ESAB was hindered by the students' underachievement, absenteeism and lack of motivation. In order to overcome such obstacles, we decided to work on a new design for the subjects with a substantial increase in the use of computer-assisted methodologies. Therefore, we designed a methodology based on the use of electronic tools aiming at solving standard problems and fostering lecturer-student communication.

At the end of each semester of the academic years 2009/2010 and 2010/2011, we asked our students to rate certain aspects of the quizzes performed and of the use of Moodle. Even though this is not the only source of feedback, the students' ratings provide an excellent guide for designing the teaching process and, in particular, for assessing student motivation. The interaction between the lecturer and the learner helps the former to adapt the learning and assessment tasks to the latter's needs (Daly et al., 2010). Table 5 gives a summary of their answers.

The students were also invited to note down the positive and negative aspects of the quizzes. It is important to underscore the following positive aspects, as expressed by the students themselves:

"It is an easy way to put into practice the theoretical concepts learnt in class"

"Quizzes are entertaining"

"Quizzes provide an instantaneous correction of my responses"

"Quizzes helped me to be in contact with the subject"

"It is an indirect way to enhance the study"

When it comes to the negative aspects, the students not only tended to regard the time available to perform a quiz as insufficient, but they also complained about the poor feedback provided once

the quizzes had been performed. Moreover, when asked what improvements they would suggest, the students placed emphasis on getting more feedback on the answers.

Yet, from the results shown in Table 5 and the positive and negative aspects mentioned above, our overall impression is that the students of Mathematics 1 and 2 regarded the quizzes performed positively, both in 2009/2010 and in 2010/2011.

Here it should be noted that the authors undertook a similar project dealing with Moodle quizzes on a Statistics course (Blanco and Ginovart, 2010a). The results of this experience, in keeping with the results obtained in Mathematics 1 and Mathematics 2, would support the advisability of using this type of formative assessment in teaching and learning in higher education.

Table 5. Mathematics 1 and Mathematics 2: The students' ratings.

QUESTION	2009/2010 M2 n=83 (%)	2010/2011 M1 n=158 (%)
Have you used Moodle before on this course?		
Not at all	21.7	7.0
Rarely	30.1	16.5
Sometimes	32.5	53.8
Often	10.8	17.1
Always	4.8	5.7
Overall, I would rate the quizzes performed as		
Very poor	0.0	3.1
Poor	12.0	8.8
Satisfactory	41.0	40.9
Good	33.7	40.3
Very good	13.3	6.9
The quizzes helped me to understand some of the topics covered in the theoretical classes	4.8	6.3
Strongly disagree	15.7	8.2
Disagree	21.7	36.1
Neutral	42.2	41.1
Agree	15.7	8.2
Strongly agree		
Once answered, I got enough information about correct answers		
Strongly disagree	4.8	8.2
Disagree	22.9	22.0
Neutral	31.3	34.6
Agree	30.1	25.8
Strongly agree	10.8	9.4
Performing the quizzes has made me more interested in the subject		
Strongly disagree	2.4	8.2
Disagree	16.9	16.5
Neutral	41.0	52.5
Agree	30.1	17.7
Strongly agree	9.6	5.1

QUESTION	2009/2010 M2 n=83 (%)	2010/2011 M1 n=158 (%)
I think my scores in quizzes were fair		
Strongly disagree	3.7	2.5
Disagree	4.9	3.8
Neutral	25.6	19.6
Agree	41.5	53.2
Strongly agree	24.4	20.9

4. Conclusions

This paper has presented the results obtained from two projects subsidised by the Institute of Education Sciences at the UPC, the main aim of which was to design and implement a number of Moodle quizzes for the formative e-assessment of students enrolled on mathematics courses for Engineering bachelor's degrees. Subsequently, the reliability of the quizzes as assessment tools was analyzed to ensure the quality of the e-assessment system proposed.

Following the ENQA's report about the standards and guidelines for quality assurance in European higher education, the design and development of the Moodle quizzes involved a reflection that was clearly motivated by the diverse aspects of the teaching-learning process, on the part of the lecturer and the learner.

First of all, it was fundamental to prove whether the consistency of the e-assessment system used aligned with that of the traditional assessment tools used so far. The correlation between scores in the quizzes and the final mark of each subject (Mathematics 1 and Mathematics 2) for the years 2009/2010 and 2010/2011 showed that Moodle quizzes could be regarded as a suitable tool to inform students of their performance throughout the learning process. In addition, the particular use of the quizzes as low-stakes assessment activities for chapter checking contributed to the promotion of student self-regulation and regular work throughout the year. Therefore, this paper provides evidence that Moodle quizzes represent a consistent alternative to open-ended tests in terms of continuous and formative assessment.

In order to meet the requirements of formative assessment, the e-assessment system had to supply tools for the lecturers to adapt an activity to the learners' needs, thus improving its reliability from the feedback obtained. The item analysis provided by Moodle's quiz module turned out to be an interesting psychometric tool to estimate, refine and improve the reliability of quiz questions. In relation to the psychometric analysis performed with the 14 quizzes and with the responses of around 500 students, we achieved a significant step forward in the treatment and comprehension of two indicators, namely, the Facility Index and the Discrimination Coefficient.

Finally, a key aspect in the design and development of the e-assessment system was to check whether the students had a favourable view of it. The fact that the students' ratings of the Moodle quizzes were very positive reinforced the idea that activities of this kind were suitable for mathematics

teaching and learning. But not solely mathematics, since the system could be extrapolated naturally to other courses. The results reported in this paper, as well as the students' attitudes, are very encouraging in terms of continuing to work with this e-assessment system and even extending it to other disciplines in the future.

The experience acquired in the development of the reported projects, together with the data generated by the implementation of the quizzes, allowed us to visualize an optimal way to drive forward the effective use of Moodle's quiz module for the formative assessment of students in keeping with the EHEA guidelines. It is worth noting that, by means of this e-assessment system, we managed to carry out the continuous formative assessment of a considerable number of students without overburdening the lecturers with marking or jeopardising assessment quality. This would not have been possible if we had not made full use of Moodle as the LMS supported by our university; this greatly facilitated not only the implementation of tools, but also the collection and analysis of the results. In short, from the results presented in this paper, we can conclude that Moodle quizzes are a consistent and reliable tool for formative e-assessment and consequently we hope that our study will become a reference for further uses of the quiz module.

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