



# MOODLE QUIZZES FOR ASSESSING STATISTICAL TOPICS IN ENGINEERING STUDIES

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**Abstract:** In 2005 the virtual campus Atenea of the Universitat Politècnica de Catalunya (UPC) started to use Moodle, an open source learning management system that offers a wide variety of teaching tools. One of these tools, the quiz module, represents an alternative to traditional face-to-face courses and paper-based testing. In order to explore how to apply this new tool, in 2008 we started to carry out some projects subsidised by the Institute of Education Sciences of the UPC. These projects cover the compulsory undergraduate subjects in applied mathematics and statistics included in the first and second year syllabuses for all branches of engineering. The main aim of these projects is to design, implement, assess and revise a substantial bank of quiz questions and quizzes created for those courses. This contribution is centred on Statistics, a subject taught at the School of Agricultural Engineering of Barcelona (ESAB) in Spain. This contribution focuses on the assessment of six Moodle quizzes performed in the second term of the current year. In particular, the aims are to analyse students' answers, to carry out a psychometric analysis to identify the appropriateness of the questions stated in the quizzes, and to assess student ratings on this activity as a guide for improving the teaching process. The quizzes were designed to be worked out in computer lab sessions and for chapter checking as an autonomous study. From this first and positive experience regarding the Moodle quiz module in the subject of Statistics, we intend to redesign some of the quizzes in the future, taking into account not only the results supplied by the psychometric analysis, but also student results and ratings of the activity.

**Keywords:** Moodle quizzes, statistics, engineering studies.

## 1. Introduction

In 2005 the virtual campus Atenea of the Universitat Politècnica de Catalunya (UPC) started to use Moodle, an open source learning management system that offers a wide variety of teaching tools [1]. One of these tools, the quiz module, represents an alternative to traditional face-to-face courses and paper-based testing. In order to explore how to apply this new tool, in 2008 we started to carry out some projects subsidised by the Institute of Education Sciences of the UPC. These projects cover the compulsory undergraduate subjects in applied mathematics and statistics included in the first and second year syllabuses for all branches of engineering. The main aim of these projects is to design, implement, assess and revise a substantial bank of quiz questions and quizzes created for those courses [2,3]. This contribution



is centred on Statistics, a subject taught at the School of Agricultural Engineering of Barcelona in Spain, in the second year (60 lecturing hours), covering the topics of exploratory data analysis, probability and random variables, and basic statistical inference. The European Higher Education Area (EHEA) promotes a student-centred system based on the student workload required to achieve the objectives of a study program. In particular, this system favours the students' autonomous work and the formative assessment of student performance. In this context, problem solving plays a very significant role. Some teaching activities have already been performed following the guidelines of the EHEA [4-6]. This contribution focuses on the assessment of six Moodle quizzes used in the second term of the current year. Specifically, the aims are to analyse students' answers, to carry out a psychometric analysis to identify the appropriateness of the questions contained in these quizzes, and to assess student ratings on this activity as a guide for improving the teaching process.

## 2. Design of Moodle quizzes for the assessment of Statistics

To supervise students' progress at different stages of the learning process, 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 [7]. This contribution focuses on the set of Moodle quizzes that were designed to be worked on and for chapter checking as an autonomous study, either in computer lab sessions or as homework. The topics covered by each of the six quizzes in Statistics are shown in Table 1 and were aligned with the learning goals and required outcomes of the course. Since different kinds of questions can help develop different skills, the quiz questions used in these quizzes were of several types: multiple-choice questions, true/false, short-answer questions, numerical questions, matching questions and embedded answer questions (Table 2). We are well aware that multiple-choice exams are not the most suitable to provide information about the learning process [8]. However, in our course students' progress is assessed by a weighted combination of a written test during the semester (Exam 1), a cumulative final written exam (Exam 2), computer lab sessions and several homework and coursework assignments, including a project. It is within this combined assessment framework that the quizzes have to be considered.

On the other hand, we tried out more sophisticated types of question, such as embedded answer (or cloze) questions. This question type allows us to formulate more complex questions and to provide more accurate information on the process of problem solving. This fact was all the more convenient in connection with the unit of statistical inference, because in a single cloze question we could evaluate different aspects, such as hypotheses, test statistic, sampling distribution, critical values or rejection/non-rejection of the null hypothesis.

Table 1. Topics covered by quizzes in Statistics.

Q1	Q2	Q3	Q4	Q5	Q6
Exploratory Data Analysis	Probability and Combinatorics	Discrete Random Variables	Continuous Random Variables	Statistical Tables	Confidence Intervals and Hypothesis testing



Table 2. Number of questions and question types. \*Q5: random quizzes of 10 questions, from a bank of 20 short-answer questions and 20 multiple-choice questions.

	Number of questions	Multiple - choice	True / false	Matching questions	Short or numerical answer	Cloze
Q1	15	8	3	2	2	
Q2	10				10	
Q3	10	9		1		
Q4	10	10				
Q5	10	*			*	
Q6	10				1	9

Since assessment is one of the most important activities in education, feedback on performance plays a relevant role in the teaching-learning process. Getting quick feedback after a quiz is a useful tool for students to evaluate their own activity and helps them become more successful, as they can analyse their own way of thinking and begin to understand why an answer is not correct. Besides, involving frequent, low-stakes assessments during the course provides a very flexible system for evaluating student achievement, keeps students engaged in the class, and may reduce the rate of anxiety before infrequent, high-stakes tests. Our preference here was to allow students to go over their responses, the correct answers and their grades once the quizzes were completed. This was of particular relevance in Q5, where several trials allowed students to acquire sufficient skill in the use of statistical tables. Our study fits conveniently into Garfield's approach to assessment in statistics teaching, in the sense that we took into account several types of reasoning skills when creating the questions, involving data, representations of data, statistical measures, uncertainty and samples, among others [8-10].

### 3. Analysis of results

#### 3.1 Analysis of students' results

In the context of our project, the quiz module from Moodle provided information about which questions our students got wrong or partially right, overall quiz results and individual responses.

Two groups were involved, A and H, of 13 and 35 students, respectively. Table 3 shows the descriptive statistical analysis of the students' results in the quizzes. From these results we carried out a correlation analysis between the scores of the exam held in the first part of the course (Exam 1) and the marks of the quizzes answered. We performed a regression analysis relating the score mean of the first four quizzes to the marks of Exam 1. Figure 1 shows that correlation between the mean of the first four quizzes and Exam 1 is positive ( $r = 0.435$ ). In addition, linear regression is significant ( $p$ -value = 0.008). As the analysis displays a good correlation, Moodle quizzes can be regarded as a convenient tool to inform students of their performance throughout the learning process.



Table 3. Descriptive statistical analysis of the quizzes' results. N: Number of examinees, N\*: Number of non-examinees, SE: Standard deviation of the mean, CV: Coefficient of Variation, P<sub>25</sub>: Percentile 25%, P<sub>75</sub>: Percentile 75%.

	Group	N	N*	Mean	SE	CV (%)	P <sub>25</sub>	Median	P <sub>75</sub>	%Pass
Q1	A	9	4	7.3	0.54	21.9	7.2	7.3	7.9	88.9
	H	24	11	8.0	0.39	23.8	6.5	8.6	9.5	91.7
Q2	A	9	4	5.3	0.47	26.5	4.0	5.0	7.0	55.6
	H	25	10	7.3	0.47	32.2	6.0	8.0	9.0	84.0
Q3	A	11	2	8.4	0.61	24.1	6.0	9.0	10.0	100
	H	26	9	7.6	0.44	28.7	6.0	8.0	10.0	92.3
Q4	A	11	2	6.9	0.51	24.6	9.3	6.0	8.0	81.8
	H	19	16	6.4	0.77	53.2	4.0	6.0	10.0	73.7
Q5	A	11	2	9.1	0.31	11.4	8.6	9.3	9.9	100
	H	11	24	7.5	0.56	24.6	6.0	7.0	9.3	90.9
Q6	A	13	0	5.8	0.81	50.3	3.5	6.7	7.9	69.2
	H	21	14	6.0	0.46	35.3	4.3	6.7	7.3	76.2

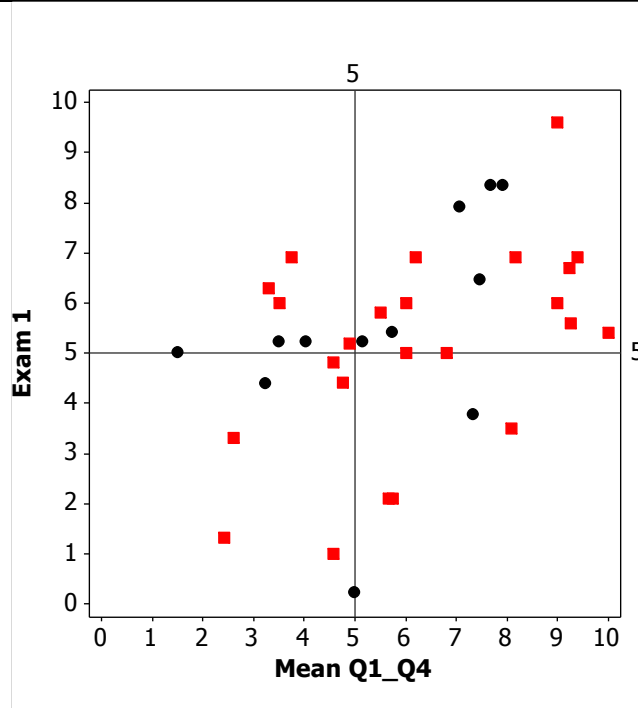


Figure 1: Scatter plot of the mean of the students' scores in quizzes Q1, Q2, Q3, Q4 versus Exam 1 scores. Sample size = 36 (12 missing values). Round bullets for group A and square bullets for group H.

### 3.2 Psychometric analysis

Psychometric analysis is a great tool for assessing whether the questions are suitable enough to discriminate between good and bad performers. All the statistical reports can be downloaded as a worksheet file, rendering all the information easier to manage. In this section we analyse the psychometric quality of the assessments, which can help us to answer whether the questions are well chosen in order to demonstrate concepts and of an appropriate level of difficulty, and whether the questions discriminate between higher and lower mathematical abilities [11].



Moodle offers a range of resources to carry out a psychometric analysis of a particular quiz, namely the Facility Index (FI) and the Discrimination Coefficient (DC). The FI describes the overall difficulty of the questions. This index represents the ratio of users that answer the question correctly. In principle, a very high or low FI suggests that the 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, ranging from -1 to +1. This is another measure of the separating power of the item to distinguish proficient from weak learners. Here we are focusing on the analysis of these two indicators.

The fact that the two groups A and H had separate entries to the virtual campus Atenea did not allow us to run a single overall psychometric analysis. So the analysis was restricted to the group with the greatest sample size, group H. Table 4 shows a brief summary of the psychometric analysis for the first four quizzes performed by group H. Here Q5 is not included since there was no point in analysing the psychometric coefficients of the random questions involved. On the other hand, Moodle does not perform the psychometric analysis of cloze questions and therefore Q6 is not included in Table 4 either. Concerning the FI, Table 4 shows the range of values and the percentage of questions with values between 15 and 85 for each quiz to discard too low and too high values. As for the DC, values are classed into three categories: Low ( $DC \leq 0.33$ ), Medium, High ( $DC \geq 0.66$ ). For each quiz Table 4 presents the percentage of questions in each of these three categories. Those quizzes with just a few questions with FI values between 15 and 85 should be newly constructed, as well as those with low values of DC [2,3].

Table 4. Psychometric analysis of quizzes Q1, Q2, Q3 and Q4 (group H).

	%FI		DC		
	Range	(15,85)	% Low	% Medium	% High
Q1	46 - 96	53	20	60	20
Q2	46 - 88	70	-	70	30
Q3	54 - 92	70	10	70	20
Q4	45 - 80	100	-	20	80

For instance, FI ranges from 46% to 96% for Q1, whereas it ranges from 45% to 80% for Q4. The high values for FI in Q1 are in keeping with the fact that 20% of the questions show low values for DC. On the contrary, Q4 shows no questions with low DC. For next year, we set ourselves the goal of revising and reconstructing those quizzes with low values for DC or too low / too high values for FI. From the information provided by Moodle, the revision of the quizzes turns out to be more feasible in that only those questions with either very low or very high FI values should be rewritten, as well as those with low values of DC.

For example, the following question in Q1 showed a really high value for FI (96%) and a rather low value for DC (0.283):

*“The standard deviation of an exam’s grades is 2. After having marked the exams, the teacher realises that one of the questions was wrongly formulated and decides to increase all the marks by one point. Then the new standard deviation will be:*

- Equal to 2.*
- Smaller than 2.*



c. *Larger than 2.*

d. *The information provided is not sufficient to answer this question”.*

Therefore, this question should be revised for the following year.

### **3.3 Analysis of student ratings of Moodle quizzes**

Students were asked to rate some items regarding certain aspects of Moodle quizzes and workload. The improvement of one's own teaching relies largely upon the knowledge of how a class is going and where changes may be needed or attempted. At the end of the semester in our university, students usually rate the importance of items regarding learning, satisfaction, course characteristics and coursework. This year they were also invited to comment on the development of the quizzes they performed in computer lab sessions or as homework assignments during the course. Though not the only source of feedback, student ratings provide an excellent guide for designing the teaching process and, in particular, for assessing their motivation. Therefore, at the end of the course students rated the quizzes as a teaching-learning activity. Figure 2 shows the results of this survey. Relative to other courses, 55% of the students considered the workload for Statistics to be reasonable and only 25% thought that it had been heavy. Nearly half of the students had never, or only seldom, used Moodle before taking this course. According to 76% of the students, the pace at which the quizzes were presented was about right. Of the students who performed the quizzes, around 95% of them regarded the activity positively. According to 76% of the students, the quizzes helped them to understand some of the topics covered in lectures (55% of the students agree and 21% strongly agree). Regarding information provided once the quizzes were answered, 50% of the students agree but 20% disagree or strongly disagree. Actually this rating matches with some of the negative aspects mentioned by students. When it comes to “Performing the quizzes has made me more interested in the subject”, this item was not as well rated as the items already discussed, and just 32% of the students agreed or strongly agreed. Finally, 67% of the students agreed or strongly agreed with their scores on quizzes. In short, our overall impression is that students of Statistics regarded the quizzes performed positively.

### **4. Conclusion**

Moodle quizzes can be considered as a convenient and interesting tool to inform students of their performance throughout the learning process. From this first and positive experience regarding the use of the Moodle quiz module in the subject of Statistics, we intend to generate improved quizzes suitable enough for assessing the teaching and learning of the subject.

To help boost more effective, dynamic and autonomous learning, our purpose is to redesign some of the quizzes in the future, taking into account not only the results supplied by the psychometric analysis, but also student results and ratings of the activity.

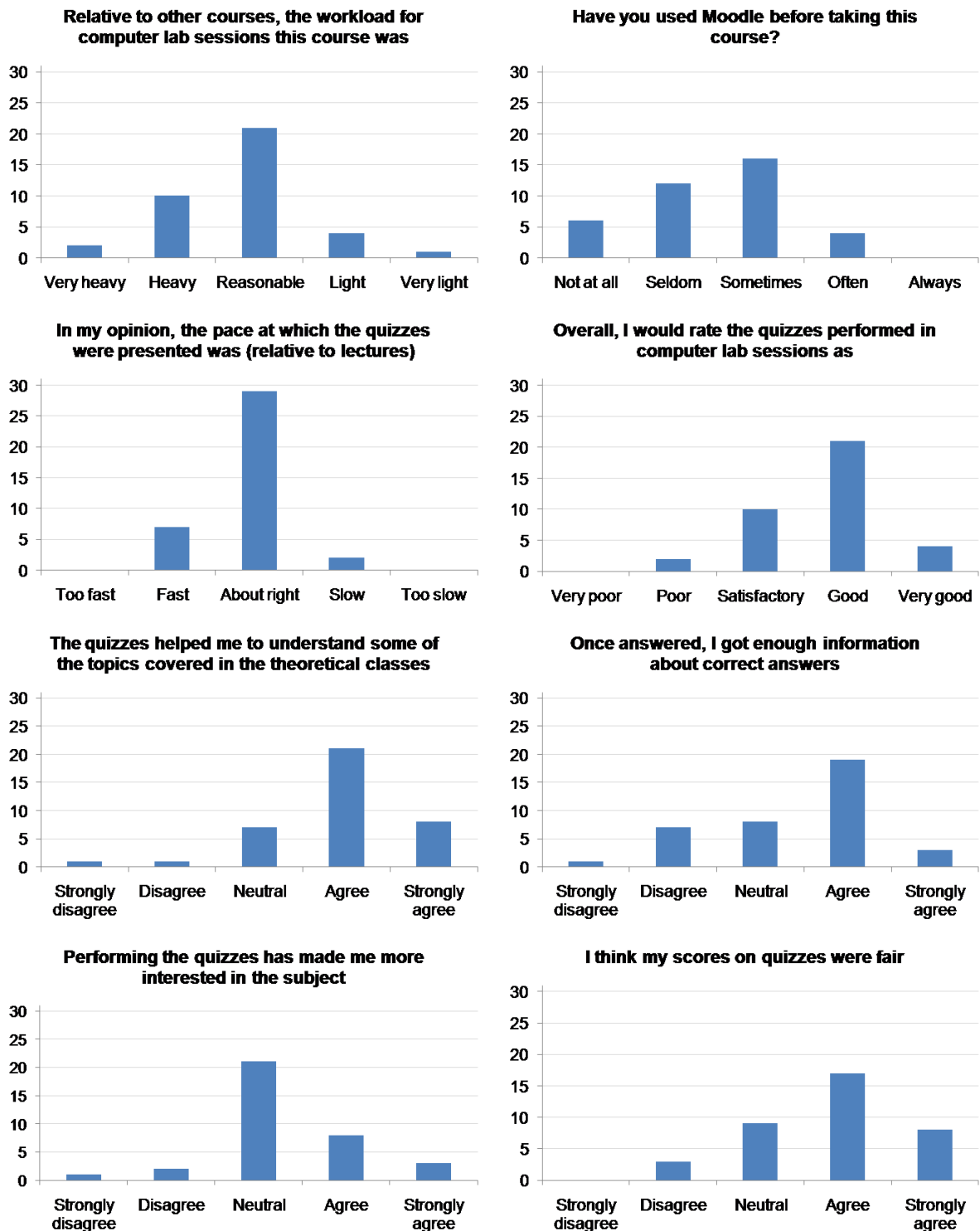


Figure 2. Student ratings of the quizzes activity.

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