Evaluation and analysis of the application of interactive digital resources in a blended-learning methodology for a computer networks subject

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Abstract

This paper shows the successful application of a blended-learning methodology using a set of interactive digital resources. This work has been developed for the subject Data Transport Systems, which is about computer network systems and is taught in the Computer Science Engineering degree at the University of Alicante, in Spain. These new resources are based on interactive user guides for the practical exercises, created as SCORM objects, self-assessment and qualification questionnaires. The set of digital resources has been included in a web learning platform based on Moodle with two main objectives: to stimulate the autonomous learning by providing interactivity between students to make flexible the way how the students study, and to facilitate the implantation of subjects in the new European Space of Higher Education system by using tools which offer collaborative surroundings. The results obtained show that this method has provided more flexibility and autonomy to the learning process and it has improved students' marks, in comparison with classical teaching and learning.

Keywords: blended-learning, digital resources, Moodle, SCORM packages, self-assessment.

1 INTRODUCTION

Blended-learning can be defined as a model for learning that combines face to face education with the web technology applied to e-learning ('electronic learning') [1] for distance education. In contrast, the concept of e-learning is used to define a learning model where the students rarely or never meet face to face, that is, the students are only supported by online courses based on web technology. This paper shows the application of this educational methodology completed by a set of interactive digital resources. These resources are based on interactive user guides for the laboratory exercises, created as SCORM objects [2], self-assessment and qualification questionnaires, managed by the web learning platform Moodle [3].

In order to analyse the results that the new materials and the educational methodology employed have had on students' learning, a complete study based on the scores of all questionnaires (both self-assessment and evaluation questionnaires) has been carried out. In addition, the student's opinion about the new interactive digital resources developed for the subject has been also analysed.

As this paper describes, the results of the study indicate that this work has been helpful and useful to improve students' learning. Moreover, students' opinion shows that they rated very well the new materials used in the course and they also believe that the evaluation questionnaires are well suited to the contents of the subject.

This paper is organized as follows: Section 2 describes the educational methodology employed. Section 3 explains how the digital resources used in the course have been created and published by the authors. Section 4 shows the results obtained

2 EDUCATIONAL METHODOLOGY

Data Transport Systems covers the study and experimentation of specific and current technologies of data networks, as for example LANs (local area networks) like Ethernet or WiFi, remote connections through VPNs (Virtual Private Networks), IP (Internet Protocol) routing or QoS (quality of service) control. Previously to this subject which is taught in the second quarter of the academic year, students have to study another subject about the basic concepts on networking in the first quarter. This other subject is called Computer Networks and a similar study about it was shown in [4].

Due to its technical character, the practical experimentation is a very important part of the subject. This experimentation is carried out in a laboratory which has specific equipment for computer networks, located in the Polytechnic School at the University of Alicante so that the exercises proposed to students are similar to common situations of the professional world. This also determines

that student must attend the lab to solve the majority of exercises. The student's homework focuses on preparing the experiments before their implementation, and reviewing and analysing the results.

This section focuses first on describing how the laboratory work proposed to the student is organized and evaluated using the interactive materials explained after in Section three. Then, the way in which this methodology has been evaluated will be described.

2.1 ORGANIZATION AND EVALUATION OF LABORATORY CLASSES

In the laboratory, each student has to work with a computer where the necessary software tools are available. It is worth to mention that all the used tools are free software. To guide students in the experiments, the student is provided with practical manuals which, on the one hand, explain the basic skills required and the tools used, and, on the other hand, describe the experiments to be performed in a sequential and constructive way. In addition, the teacher briefly explains the main concepts and organizes the work at the beginning of each session.

The experiments are organized as three main blocks, each one of which includes several experiments and has four sessions of two hours. The content of these experiments will be detailed in Section 3. The student must complete the experiments raised, individually or with help from his teammates, and with the support of the teacher. It is intended that students learn by solving problems within the topics addressed in accordance with the philosophy of constructive and collaborative learning.

The evaluation of the skills acquired by students is performed by a test at the end of each block of experiments, which has a maximum duration of one hour. Each of these tests offers the same type of issues that arise in practice manuals, and the student can use all the tools and equipment he used in practice to resolve the tests. In addition, following the test session the teacher reviews the results of students who requested them and the students who get a low score. For the final assessment of the laboratory, the student's attendance and class participation are also taken into account.

The above process is completed in the academic year 2010-11 by manuals with interactive and static formats, and especially through self-assessment activities, as described in Section 3.

In addition, along the course, the teacher also teaches the students how to resolve specific cases about configuring data routing with IP, using exercises and examples that are solved in class, with the participation of students. The skills acquired on this type of problems are evaluated with a fourth test, which is a particular problem for data routing configuration. This test does not require the use of the laboratory. For this part there are not self-assessment activities, although the student has a collection of exercises and teacher support along the laboratory sessions.

As mentioned before, the realization of practical experiments requires the student's attendance at the laboratory, but there are some questions that students can experience outside. In addition, for proper monitoring of the practices, the student requires a work outside the laboratory on the preparation of the experiments and subsequent analysis, in order to deal more successfully with the assessment tests. This is where the addition of b-learning techniques can help students [5], especially through interactive materials and self-assessment activities which are accessible through the Web.

2.2 ASSESSMENT OF THE PROPOSED METHODOLOGY

To analyse the degree of success of the proposed methodology, it is necessary to know how new materials and teaching methods applied in the laboratory exercises affect student learning. This knowledge has been extracted in two ways. On the one hand, the marks obtained by students who have used new materials and methods have been compared to other students who have not. On the other hand, the final qualifications of students have been compared with the results of self-assessment tests. The results of both studies are detailed in Section 4.1.

For the first study, the authors of this work initially thought to define two groups of students for the laboratory. But, soon it was concluded that it was difficult to plan the course with two different student groups. Besides, that would cause inequality of opportunity in the evaluation of the subject. So, finally, it was opted for all students in this academic year 2010-11 working with the new materials and methods, and the comparison was made between the students of last course and the previous 2009-10. This comparison is valid for several reasons: the students of the two courses have the same profile, the content of the previous course is very similar to the last one, the same laboratory and equipment has been used, and teachers are the same.

Finally, it has also been made a questionnaire to assess student opinion regarding new materials and the self-assessment test, and, in this way, to know the degree of acceptance of the new methodology. Section 4.2 shows the results drawn from this survey of opinion.

3   DEVELOPMENT OF THE DIGITAL RESOURCES

This section describes in detail the digital materials which have been created by the authors and published in a web site based on the popular LCMS Moodle [3], which is available in the University of Alicante as a corporative site: Moodle-UA.

3.1   CONTENTS AND ASSESSMENT

The authors have taken the contents of the laboratory classes of the previous year as a start point for the new materials of the year 2010-2011 because the proposed experiments are very interesting for the professional future of the students in the field of computer communications. Therefore, the practical classes at the laboratory have been organized in the following three practices:

- *Practice 1: Dynamic Routing with IPv4*: This practice deals with the routing protocols and the translation of IP directions.

- *Practice 2: Tunnels and Virtual Private Networks (VPN)*: This practice presents the configuration and operation of remote access to private networks.

- *Practice 3*: *Quality of Service Control and Analysis of WiFi networks:* This practice describes the mechanisms that restrain or guarantee the bandwidths of a network and the analysis of wireless network traffic.

The knowledge and skills achieved by the students are assessed by a questionnaire which is performed at the end of each practice. These questionnaires propose experiments which are similar to those experiments performed by the students during the development of the practice and they are also completed in the laboratory. Three questionnaires have been implemented in Moodle-UA, one for each practice and a final written exam have been proposed for the assessment of the routing exercises. Each of these three tests represents a 25% of the final score of the practical classes.

3.2   CREATION OF THE TEACHING MATERIALS

In previous years, the materials for the practical classes of the subject "Data Transport Systems" were based on static manuals of the three practical experiments for the laboratory sessions, a group of exercises about routing, schemes of the network structure of the laboratory and slides with the presentations of the teachers. The manuals of the practices have been improved this year by including technical information about standards and technologies. This update is very important for the students not only in order to teach them the last technologies but also to give them a general view of the behaviour of the technologies that are taught during the practical classes and which are commonly used in the professional environment.

Figure 1 depicts the snapshot of the Moodle-UA webpage where students can access to the materials of the subject. The traditional materials mentioned above (i.e. manuals, schemes, slides and exercises) are still provided but students can also access to new interactive manuals and self-assessment questionnaires.

Figure 1: Snapshot of the webpage with the materials for the subject in Moodle-UA.

These interactive manuals complement the traditional static materials of previous years which can be continue to be downloaded as pdf files. The interactive versions of the manuals allow the student to easily navigate along the contents of the practice and answer interactively to questions which are inserted in these manuals. These web manuals have been created as SCORM packages [2] by the Wimba Create application [6] since they can be easily imported as activities in Moodle. Figure 2 shows an example of several sections of these new manuals. Since all these materials and the assessment questionnaires are available in the webpage of the subject in Moodle-UA, they can be easily accessed by all the students through Internet anywhere so that b-learning methods can be applied.

Figure 2: Snapshots of several sections of the new interactive manuals based on SCORM.

3.3 ASSESSMENT AND SELF-ASSESSMENT QUESTIONNAIRES

Assessment and self-assessment questionnaires have been developed as questionnaires activities in Moodle-UA. This method has many important advantages: the variety of different types of questions, automatic correction, the possibility of reviewing the students' answers and the easiness of importing/exporting information about the results of the exams.

The questions developed for these questionnaires are based on two different types: multiple choice and cloze. Multiple choice questions make students choose the best option in a list of several alternatives (as shown in Figure 3). Cloze questions allow developing more general questions where students have to fill textboxes (with strings and/or numbers) and/or choose an option in a list (as shown in Figure 4).

Figure 3: Multiple choice question with feedback (in bold) in self-assessment questionnaire.

Figure 4: Cloze question with feedback (in bold) in self-assessment questionnaire.

These types of questions have not only been applied in the assessment questionnaires but also in the self-assessment questionnaires. The self-assessment test is available during the previous week to the exam (i.e. assessment questionnaire) and students have 4 attempts each one to complete it with a minimum delay of 30 minutes between them. When students finish an attempt of the self-assessment questionnaire, they get a general mark which identifies their knowledge of the practice and their level of preparation for the exam. For each wrong answer, students get a feedback text in order to help them find by themselves the right answer (as shown at the bottom of snapshots of Figures 3 and 4) and thus a constructive learning process is made possible.

These types of questions have also been used for the implementation of the last survey which has been answered by the students during the last week of the year in order to discover their opinions about the new materials and methods. In particular, this survey is composed by 8 multiple choice questions which are voluntary and are not considered in the mark of the subject.

3.4   COMPILATION OF RESULTS

In order to assess the effect of the new materials and the new self-assessment questionnaires over the learning process of the students, a comparison between the marks of the students has been developed. In particular, the authors have compiled the following data from the Moodle-UA platform: the marks of the three assessment questionnaires (i.e. practice exams), the marks of the three self-assessment questionnaires and the results of the final survey. In addition, the authors have also compiled the marks of the students from the previous year (2009-2010) in order to compare them with the marks of the current year. The analysis of all these data is explained in the following section of this paper. Table 1 summarizes the number of students who have done each one of these questionnaires. There were 84 students registered at the beginning of the year and 60 of them completed all the compulsory exams (since the self-assessment questionnaires were optional). Finally, 71.4% of students have completed the practical classes.

Table 1. Number of students who completed the different tests.

	Practice 1	Practice 2	Practice 3	Routing Exercise
Self-Assessment	57	60	54	*
Assessment (Exam)	80	75	73	60

* There was no self-assessment questionnaire for this test.

4   RESULTS OBTAINED

In previous works, some studies have been done to determine the degree of satisfaction of the students in relation to the teaching methodology and the e-learning process with Moodle and SCORM packets in comparison with traditional teaching methodology [4]. In addition, another study has shown how easy is to generate simulations for courses of Computer Networks based on Java applets [7] from tools as EJS [8] and KivaNS [9] and how this type of digital resources have improved the student learning process. In this study, a teaching methodology based on self-assessments tests have been designed and implemented. This way, the student is confronted the training test which measures acquired knowledge level in a similar way that the assessment test. In general, the students have welcomed this type of learning based on self-assessments.

4.1   IMPROVING THE LEARNING PROCESS WITH SELF-ASSESSMENTS

The students have performed three experiments (E1, E2, E3) about the topics of the Computer Network course. The 71.25% of students (57 of 80 students), the 80% (60 of 75 students) and the 73.92% (54 of 73 students) have participated in the self-assessments, respectively. These self-assessments can be answered one or more times. On the one hand, figure 5a shows the number of participant students on the self-assessments process per number of attempts. The majority of the students have spent two or less attempts. On the other hand, Figure 5b shows the achieved qualification by the students according to the number of attempts used to pass the final test of each experiment. In general, the majority of students have spent two attempts to achieve a qualification between 7 and 10 according to Spanish Academic Grading System (70% of the answers are correct).

a)   b)
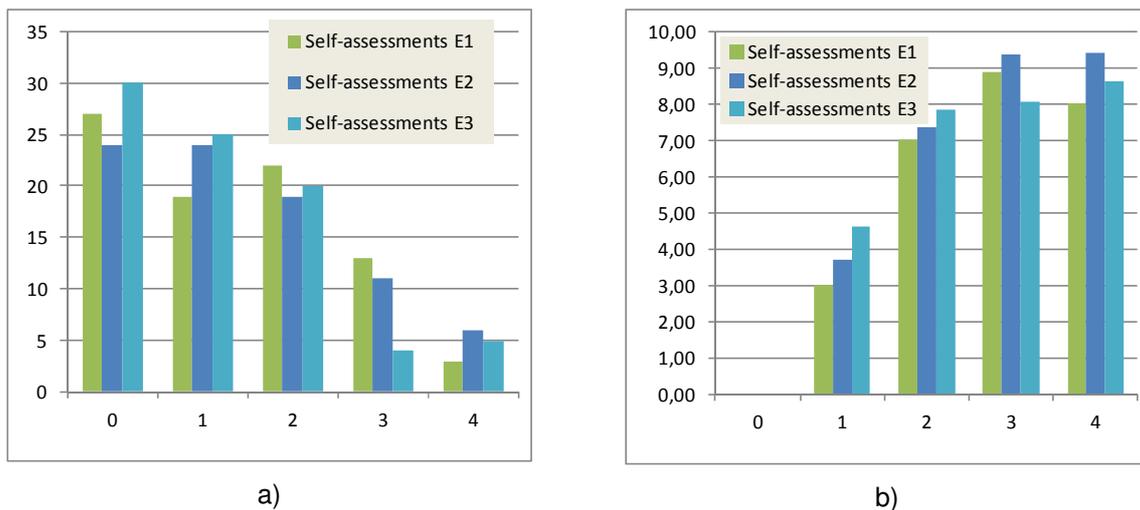
Figure 5: a) Number of participant students on the self-assessment process per number of attempts. b) Students' marks according to the number of attempts to pass the test of each experiment.

Figure 6 shows a comparison between the marks achieved by students with regard to their assessments and self-assessments. The difference is minimal when they have used 3 attempts to answer correctly the questions of test (see images from Figure 6a-6c). The Spanish Academic Grading System has been used to measure the reached level of representative knowledge. However,

this system has been transformed to the most popular grading system, the United States grade which use discrete evaluation in the form of letter grades (Figure 6d). The Spanish Grade uses a scale between 0 and 10 and the United States Grade uses a scale between 0 and 4. Furthermore, Figure 6a shows as the non-participant students (number of attempts is 0) on the self-assessments have obtained the lowest mark on the assessments.

In order to evaluate the teaching methods and how they influence the learning process, this paper presents a comparison between the students' marks of the two last academic courses: 2010 (92 students) and 2011 (84 students). In the two years, the students have the similar academic profile and thus the comparison can be done. The only difference is the self-assessments system in 2011. They did not self-assessments in 2010. This fact has allowed the students to improve their marks. These results can be observed in Figure 7. Figure 7 shows that the percentage of students with 'A' marks has grown respect to 2010 in all the experiments (E1-E3). In particular, the experiment 1 (Figure 7a) shows 8.5% with mark 'A' and 4.5% with mark 'B' more students in 2011 than in 2010. In addition, the number of non-participant students has decreased (5%). The student loses the fear of the examination. Similarly, the 23% and 17% of students achieve a mark A in the experiment 2 (Figure 7b) and experiment 3 (Figure 7c), respectively. At the same time, the number of students which do not pass the final test have decreased, 7% and 18% for the experiments 2 and 3.
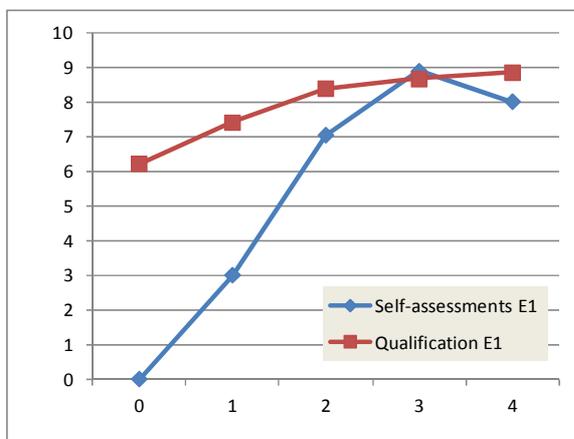

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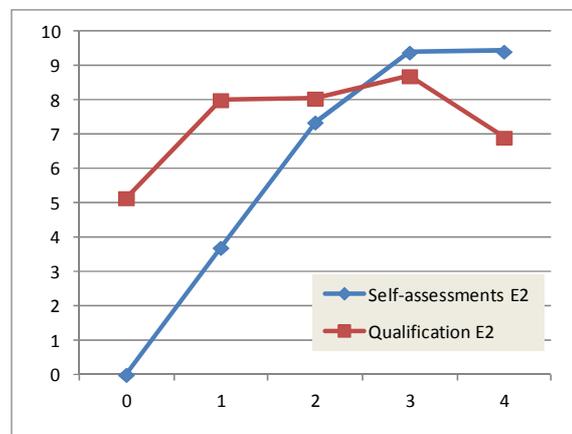
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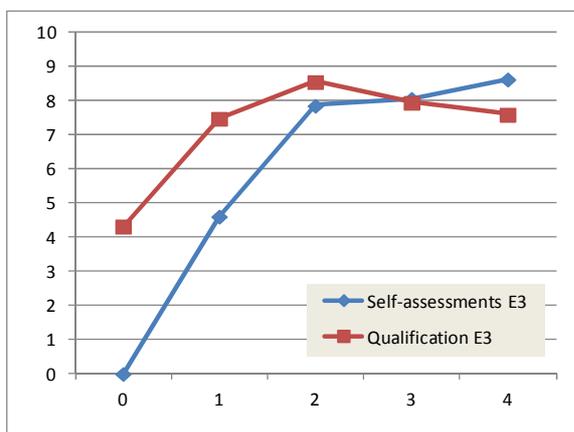
c)

| Percentages Hits/Faults	Assesments/Qualifications in Educational systems		
	in paper	Spain	USA
96-100%	A+	Excellent (9.5-10]	A (3.8-4]
91-95%	A	Excellent [9-9.5]	A (3.6,3.8]
86-90%	A-	Very Good (8.5-9)	B (3.4,3.6]
81-85%	B+	Very Good [8-8.5]	B (3.2,3.4]
76-80%	B	Very Good (7.5,8)	C (3,3.2]
70-75%	B-	Very Good [7,7.5]	C (2.8,3]
67-69%	C+	Good (6.6.,7)	D (2.6,2.8]
63-66%	C	Good (6.2,6.6]	D (2.5,2.6]
60-62%	C-	Good [6,6.2]	D (2.4,2.5]
57-59%	D+	Sufficient (5.6,6)	E (2.2,2.4]
53-56%	D	Sufficient (5.2,5.6]	E (2.1,2.2]
50-52%	D-	Sufficient [5,5.2]	E [2,2.1]
<50%	E,F	Failure [0-5)	F [0-2)

d)

Figure 6: a)b)c) Marks obtained by students in relation to the number of attempts to pass the test of each experiment (E1-E3).d) Equivalence approximated among Spanish academic grading system and USA grading system.
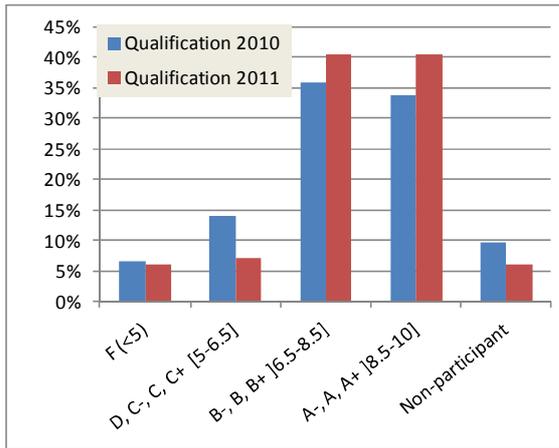
a)
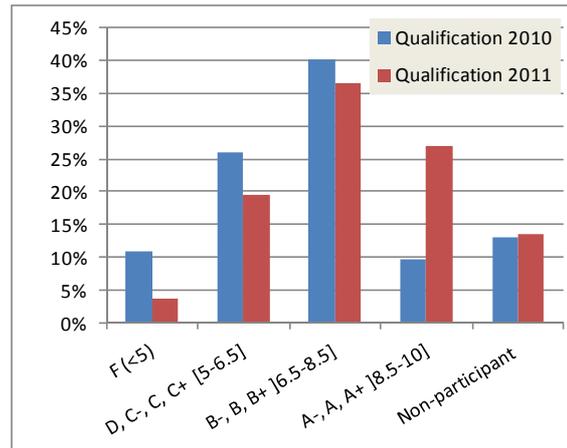
b)
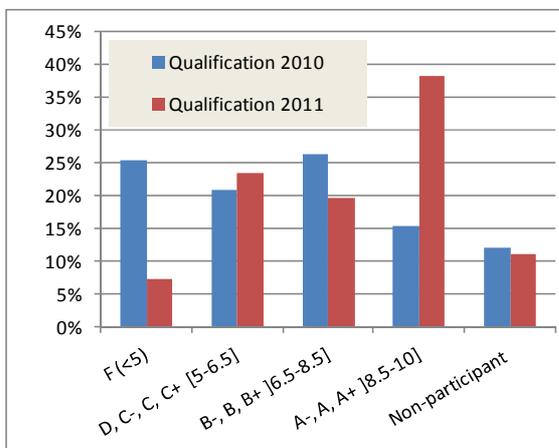
c)

Figure 7: Final qualification obtained by the students to pass the test of the three experiments realized.

4.2 STUDENTS' OPINION

An extension of the previous study was done to determine the degree of satisfaction of the students in relation to the teaching methodology in 2011. A survey has been arranged in the educational platform Moodle-UA. The survey consists of questions about the four different aspects such as assessments (Figure 8a), self-assessments (Figure 8b), types of resources (Figure 9a) and quality of experiments (Figure 9b). The survey is voluntary and it has been answered by 24 students (25%).
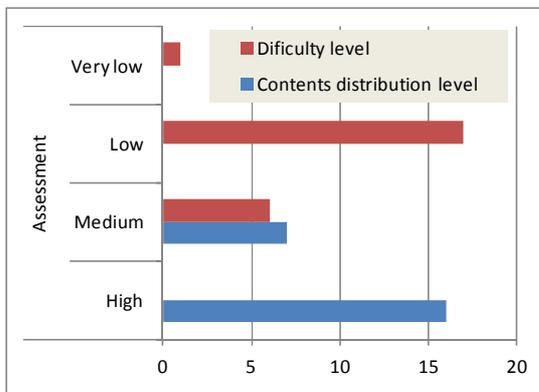
a)
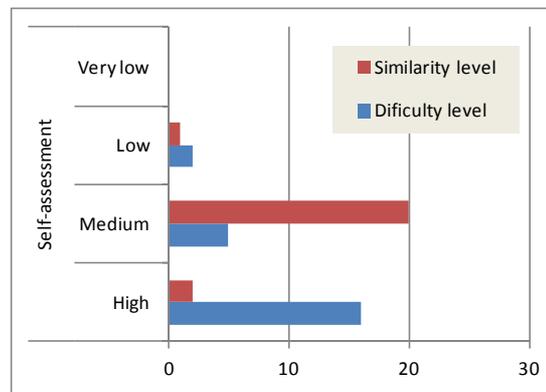
b)

Figure 8: Results of students' opinion about a): assessment exam: b) self-assessment questionnaires

Students' opinion shows the degree of satisfaction about: a) the final test used to assess the subject. b) Self-assessment tests to prepare the training to pass the final test. Seeing the Figure 8, two important conclusions can be drawn:

- The students think that the level of requirements to pass the exam (final test) is according to the contents and aspects studied in the four experiments. Figure 8a shows the contents distribution level is good (medium or high). And the majority of students think that difficulty to pass the exam is low. This means the exam is easy.

- The students think that the tests of self-assessment have been very useful to self-measure the knowledge level and skills acquired before making the exam (final test). Figure 8b shows how the students think that the self-assessment and assessments tests are quite similar though not too (majority opinion is medium). In addition, they think that difficulty level of the self-assessment tests is higher than the assessment test (majority opinion is high in Figure 8b in comparison with low-medium in Figure 8a).

Respect to the students' opinion about the educational platforms (Figure 9a) and the degree of utility of the educational resources provided by teachers (Figure 9b) in order to understand and learn concepts and topics, as well as acquire skills (Figure 9c) to pass the final test of the subject and to use it in a future job, four affirmations can be highlighted.

- The 87% of students prefer Moodle versus Virtual Campus-UA (Figure 9a) independently of the resources format (SCORM-web, PDF, etc.). Moreover, the 57% of students prefer PDF opposite SCORM-web (Figure 9a). This result contrasts with other researches carried out previously in [4]. Perhaps, it can be due to low participation in the survey. The SCORM-web provides more versatility and flexibility to add educational contents (videos, sounds, JAVA simulations, etc.).

- The students prefer assessment tests implemented by means of quiz module of Moodle (Figure 9b) versus classic test with short or long questions in paper.

- The 75% of students consider that the following of course is easy. Moreover, as final conclusion, the majority of students consider that the skills achieved are useful or very useful for their first future jobs (Figure 9c).
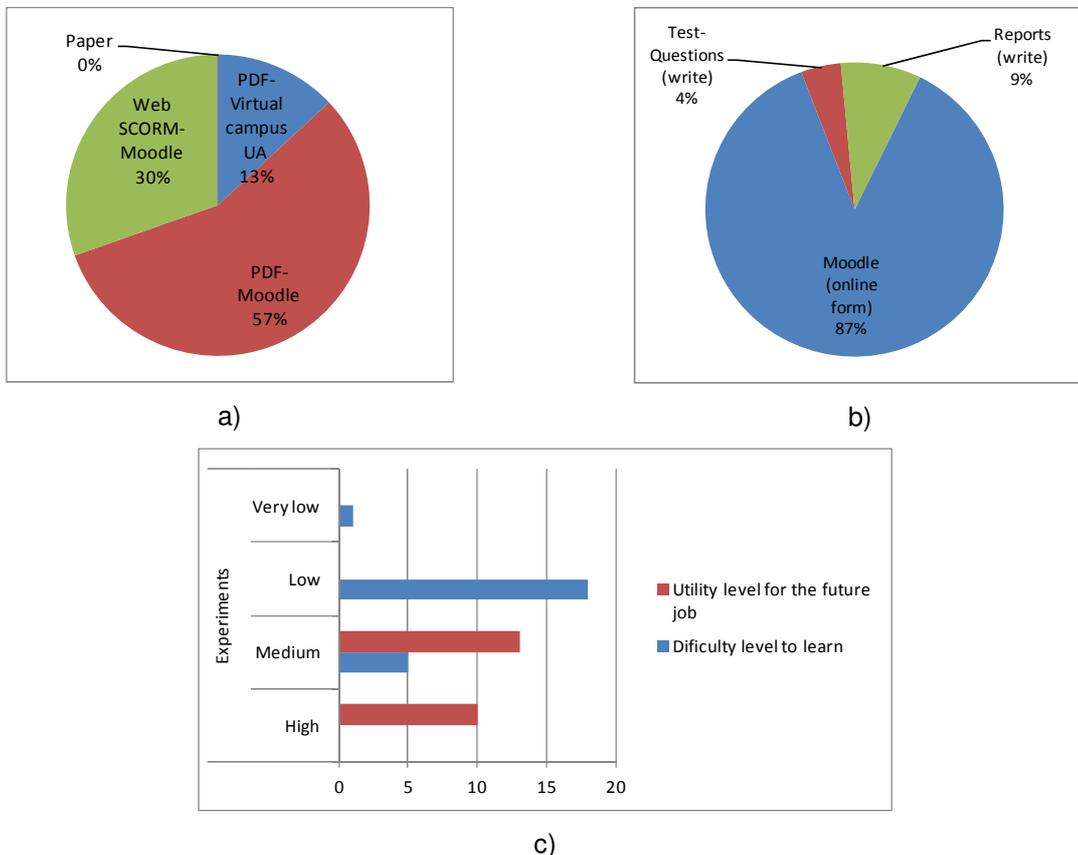

a)

b)

c)

Figure 9: Students' opinion that show their preferences about: a) the educational platform and educational resources. b) Quiz module of Moodle to do the tests. c) The quality of the experiments.

5 CONCLUSIONS

The application of a blended-learning methodology using a set of interactive digital resources for the subject Data Transport Systems in the Computer Science Engineering degree at the University of Alicante, has been effective. The resources employed are based on interactive user guides for the practical exercises, created as SCORM objects, self-assessment and qualification questionnaires, all them included in the e-learning platform Moodle.

The results of the study show that students who used self-assessment questionnaires obtained higher scores in the practical assessment test. It has also been verified that students' marks for this academic year 2010-11 have improved and the percentage of students who passed the practical assessment test is higher, both compared with the past academic year. This indicates that this work has been helpful and useful to improve students' learning. Moreover, it has been verified that qualifications were not improved when students use more than three attempts for the self-assessment questionnaires.

With regard to the students' opinion, they rated very well the new materials included in Moodle, and especially the self-assessment questionnaires. Although students believe that the practices did not have great difficulty, they are very useful for the professional world. They also believe that the evaluation questionnaires are well suited to the contents of the subject and are very similar to the self-assessment, although the distribution of the difficulty of the questions should be improved.

Finally, it is worth to mention that the blended-learning methodology using learning educational resources based on digital documents, web packages and interaction tools, has been successfully applied to provide more flexibility and autonomy to the learning process and it has improved students' marks, in comparison with classical teaching and learning.

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