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Analysis of Results of Application of a Student-Centered Learning System to Improve Performance of First-year Students*

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Analysis of the results of the application of a student-centered learning system (SCLS) aimed at achieving the objectives of the subject Analysis of Circuits I in the Escuela Universitaria de Ingenieria Tecnica de Telecomunicacion (EUITT) at the Universidad Politecnica de Madrid (UPM). The SCLS was based on the European Credit Transfer and Accumulation System and the educational experiment was carried out in the first semester of the academic year 2007–2008; a comparative analysis between the SCLS and the traditional teaching and learning system (TTLS) in the EUITT-UPM can be seen below. To conduct the statistical analysis of the data collected in the experiment and make the right decisions, both treatment and control groups were formed and several tests of the hypothesis were performed. The outcomes of the experiment were satisfactory and showed that the differences between the SCLS and the TTLS are not always significant.

Keywords: Student-centered learning system; first-year students; statistical analysis

INTRODUCTION

THE HIGHER EDUCATION SYSTEM is experiencing a continuous positive change from some teaching methodologies to others that have been shown to be more appropriate for the needs of today's students and industry.

In the Escuela Universitaria de Ingenieria Tecnica de Telecomunicacion (EUITT) at the Universidad Politecnica de Madrid (UPM), the change is from the traditional teaching and learning system (TTLS), which has failed to motivate students for further learning and does not take into consideration their needs and perceptions, to novel systems based on the student workload required to achieve the objectives of programs.

While in the TTLS credits are given for student workload in class, without taking into consideration any independent and private study, and the preparation of projects and examinations either; in the student-centered learning system (SCLS) credits can only be obtained after successful completion of the work required and appropriate assessment of the learning outcomes achieved. The learning outcomes are sets of competences, expressing what the student will know, understand or be able to do after completion of a process of learning [1].

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In short, SCLS is an active learning system based on the application of the European Credit Transfer and Accumulation System (ECTS) [1] to the EUITT-UPM. In fact, the SCLS presented in this paper was born four years ago as a result of the adaptation of the first-year course of the EUITT-UPM to the European Higher Education Area [2].

Therefore, as the current emphasis is on understanding and measuring student learning, rather than teaching [3], the content-centered approach [4] is soon to be obsolete and the current higher education system is moving on to the student-centered approach [4]. In the latter, developing the cognitive abilities of the students is of paramount importance rather than teaching, and it also applies collaborative and cooperative learning methodologies efficiently [5–6].

In the EUITT-UPM, the subject Analysis of Circuits I (AC-I) is taught in the first semester of the first-year course; it is a fundamental subject. For this reason, at university, several educational experiments aimed at improving the performance of the students in AC-I have been carried out for several years.

The overall outcomes of the experiments have shown that the academic results obtained depend on factors such as preparation of the students before entering university, assessment methods, kind of groups of students (i.e. new first-year students or students who are taking the subject again), marking scheme and teaching and learning system, among others.

Here, the statistical analysis of an educational experiment carried out in the subject AC-I in the present academic year 2007–2008) is conducted. The problem of analysis is formulated as a statistical analysis problem and some decisions about the efficiency of the proposed SCLS on the basis of sample information are made.

EDUCATIONAL EXPERIMENT

The main objective of the present educational experiment was to carry out research on one method of teaching and learning based on the student-centered approach, and show that in some cases the differences between this approach and the TTLS are significant. But in others, despite having attained better academic results with the SCLS than with the TTLS, the differences between both systems are not significant.

To this end, 222 students who had to take the subject AC-I were chosen to participate. These students were chosen at random from the group of 444 students who were enrolled in AC-I in the first semester of the academic year 2007–2008.

The 222 students were divided into four groups with the following characteristics:

- Group A: 50 new first-year students (NFYS). These students studied under the TTLS.
- Group B: 47 NFYS. These students studied under the SCLS.
- Group C: 64 students who were taking the subject again (STSA). These students studied under the SCLS.
- Group D: 61 STSA. These students studied under the TTLS.

The four participating professors were all volunteers. Two of them had good experience with the application of the student-centered approach to improve student performance, and the other two had good experience with the application of the TTLS.

The TTLS consisted of 15 teaching weeks in which the subject AC-I had allocated 7.5 non-ECTS credits. One non-ECTS credit stands for 10 working hours for students in lectures, seminars and laboratory sessions, without taking into consideration workload after classes, independent and private study and examinations. For the TTLS, the marking scheme for AC-I was constructed as follows: 75% for the final exam paper (done by the students in one day during examination weeks, after having finished the 15 teaching weeks of the semester), and 25% for the laboratory exam (in the last week of the semester).

The present SCLS consist of 15 teaching weeks in which the subject AC-I has allocated 7.14 ECTS credits. One ECTS credit stands for 25–30 working hours. However, credits in ECTS can only be obtained after successful completion of the work required and appropriate assessment of the learning outcomes achieved; student workload in ECTS consists of the time required to complete all planned learning activities such as attending lectures, seminars, independent and private study, preparation of projects and examinations [1].

Furthermore, for the SCLS it was decided to construct the marking scheme based on continuous assessment tasks as follows: two exam papers, 30%– the first exam paper (in the middle of the semester) and 37.5% the second exam paper (in the last week of the semester); 7.5%– ten 30-minute knowledge tests given to the students during all the semester (two 10-questions knowledge tests given at the end of each one of the five units of work of AC-I); and 25% continuous assessment activities in the laboratory including a final laboratory exam in the last week of the semester.

Also, students who did not have an outstanding performance during the semester had the opportunity to do the final exam paper, as in the TTLS. However, in the SCLS group, students who did have an outstanding performance in AC-I during the semester did not have to do the final exam paper; they passed the subject if their performance in the continuous assessment tasks was very good.

Materials

All the lecture rooms were designed to facilitate teamwork among students, with Wi-Fi technology, a slide projector and adjustable desks aimed at making the students feel comfortable when working in a team. In the laboratory sessions, the student workbenches were equipped with the conventional laboratory instrumentation that can be found on a telecommunications engineer's workbench.

Units of work

- Unit 1: Basic laws of electrical circuits.
  - Objectives: After studying this unit students should be able to establish the connection between the laws of electromagnetism and the electrical circuits, use the laws to analyze direct current (DC) electrical circuits and analyze the performance of passive components (i.e. resistors, capacitors and inductors) and of independent voltage and current sources.
  - Duration: 3.6 weeks.
- Unit 2: Steady-state electrical circuits.
  - Objectives: After studying this unit students should know the definition of phasor and impedance, and they should be able to apply the circuit laws learned in the previous unit to the analysis of steady-state electrical circuits. Also, they should be able to represent a sinusoidal waveform by a phasor, to analyze circuits using phasors, to calculate the equivalent alternating current (AC) impedance and admittance of basic circuits, to construct phasor diagrams for the voltages and currents

in circuits, to calculate the average power dissipation, and to analyze AC circuits with both dependent and independent voltage and current sources.
  - Duration: 3 weeks.
- Unit 3: Methods of analysis of circuits.
  - Objectives: After studying this unit students should have an understanding of the topology of circuits, know how to derive the minimum number of circuit equations to solve a circuit, know how to solve a circuit by using node and loop analysis and should be able to apply the principle of duality and source shifting.
  - Duration: 1.6 weeks.
- Unit 4: Circuit theorems
  - Objectives: After studying this unit students should understand the linearity properties of linear circuits, the Thevenin's theorem, the Norton's theorem, the Miller's theorem, the power superposition principle, the maximum power transfer theorem and the Everitt's theorem; and should be able to apply the concept of impedance matching and to calculate transmission and insertion loses.
  - Duration: 3.8 weeks.
- Unit 5: Magnetically coupled circuits.
  - Objectives: After studying this unit the students should have an understanding of the magnetic coupling phenomenon and its basic principles, Ampère's Law and Faraday's law of induction. Also, the students should be able to analyze circuits with coupled inductors, and real, perfect and ideal transformers and autotransformers.
  - Duration: 3 weeks.

Common teaching and learning methodologies

Collaborative and cooperative learning methodologies were used [5–6]. Students worked together in small groups in and outside the classroom; they interacted in purposely structured heterogeneous groups to support the learning, their own and of others in the same group in order to build cooperation skills. This learning process was carried out under the supervision of an instructor who also acted as a coach and facilitator.

In Groups B and C, scheduling of the subject followed this pattern:

1) Before each class students were encouraged to read a few sections ahead of the textbooks used in class and to discuss the material in order to come to class prepared.
2) The lecture and laboratory sessions were based on student-centered teaching strategies and student teamwork.
3) After each class students were given homework activities to be done in small groups or in independent and private study.

To promote tutor session, at the beginning of the semester, small groups of usually no more than four students, were formed and encouraged to sign up for 30 minutes-long tutor sessions in which the professors showed them the importance of tutor sessions for both each student and each small group of students, taking into consideration their strengths and weaknesses [7–8].

The continuous assessment system was applied to Groups B and C to make it possible for the students to keep up with their own progress in their studies and make improvements where needed. Also, the continuous assessment was aimed at facilitating the process of identifying strengths and weaknesses of the teaching and learning environment as well as raising the quality of teaching in each unit.

At the beginning of the semester all students were informed about the methods of assessment, the way in which student achievements were going to be examined and graded, the pass grade and the factor by which the continuous assessment was going to be weighted.

The software system used in this project was Moodle, which is a well-known free-software e-learning platform; the professors who taught the subject AC-I in the Groups B and C used b-learning (i.e. blended learning) to improve their teaching efficiency.

The virtual learning environment (VLE) was used to provide follow-up materials online, continuous assessment tasks for their (online) discussion, homework assignments and online activities or exercises. It was also used to make available the material from the professors and the scheduling of each unit of work, to participate in forums assigned by the professors and to provide forum questions and e-mentoring or e-tutoring.

To carry out collaborative and cooperative work among the professors who participated in the research, they worked together in order to elaborate and check the continuous assessment tasks and the exams for the students, to identify and define the problems of the teaching and learning methodology, to search for solutions that the rest of the professors of the subject could agree, to test out hypotheses about the solutions, and so on. During all the semester, the professors who participated in the research had at least one meeting every two weeks.

As a result of the above-mentioned collaborative and cooperative work, 200 knowledge test questions on AC-I were elaborated during the semester (i.e. 40 knowledge test questions for each unit of work). These knowledge tests were aimed at helping students to identify their strengths and weaknesses in the process of learning the contents of each unit of work.

As part of the continuous assessment activities, at the end of each unit of work each student under the SCLS had to do two 10-questions knowledge tests on the unit, in less than 30 minutes. This kind of activity was carried out using the VLE, and the tests were constructed using the platform Moodle.

It should be pointed out that the 10 questions were chosen at random from the 40 knowledge test questions that were elaborated for each one of the five units of work. Also, the professors who participated in the experiment programmed Moodle in such a way that none of the knowledge tests had the same 10 questions.

For the students of Groups B and C, it was mandatory for them to do the 10 knowledge tests (i.e. two tests for each unit of work) given during the semester. However, for the other students it was optional..

An example of the full version of one of the 10-questions knowledge tests is included in the Appendix.

ANALYSIS OF THE FINAL GRADES OF THE STUDENTS

The first step was to conduct an exploratory examination of the data. This was carried out graphically.

The R system for statistical computing was used [9]. This is a free software environment for statistical computing and graphics [10]. The data set was loaded (Gradesgroups.txt) and the variables (GroupA,GroupB,GroupC,GroupD) were accessed. Figure 1 shows the boxplot of the data. R commands were as follows:

```
> d=stack(list"A"=GroupA,"B"=GroupB,
"C"=GroupC,"D"=GroupD))
> library(lattice)
> bwplot(~values|factor(ind),data=d,layout=c(1,4),
xlab="Grade")
```

Table 1 shows some summary statistics. R commands were as follows:

```
>summary(Gradesgroups)
>tapply(d$values,d$ind,sd)
```

Next, a comparison of the two teaching methods (SCLS and TTLS) for Groups C and D was carried out.

Figure 2 shows the histogram and density estimate of the Groups C and D. R commands were as follows:

```
>dCD=stack(list("D"=GroupD,"C"=GroupC))
>histogram(~values|factor(ind),data=dCD,
type="density", xlab='Grade', ylab=",main=",
panel=panel.mipanel, layout=c(1,2))
```

The boxplot of Group C is similar to that of Group D. The length of the boxplot and the interquartile ranges of Group C are similar to those of Group D.

The data grades of Groups C and D were modeled as realizations of random samples, $X_1, \ldots, X_n$ and $Y_1, \ldots, Y_m$, from two distributions, one with expected value μ_1 and the other with expected value μ_2; the test of the hypothesis was $H_0 : \mu_1 = \mu_2$ against $H_1 : \mu_1 \neq \mu_2$ at level 0.05.

If the data are normally distributed with common variance, the test statistic (two sample t-test)

$$T = \frac{(\overline{X_n} - \overline{Y_m}) - (\mu_1 - \mu_2)}{S_p},$$

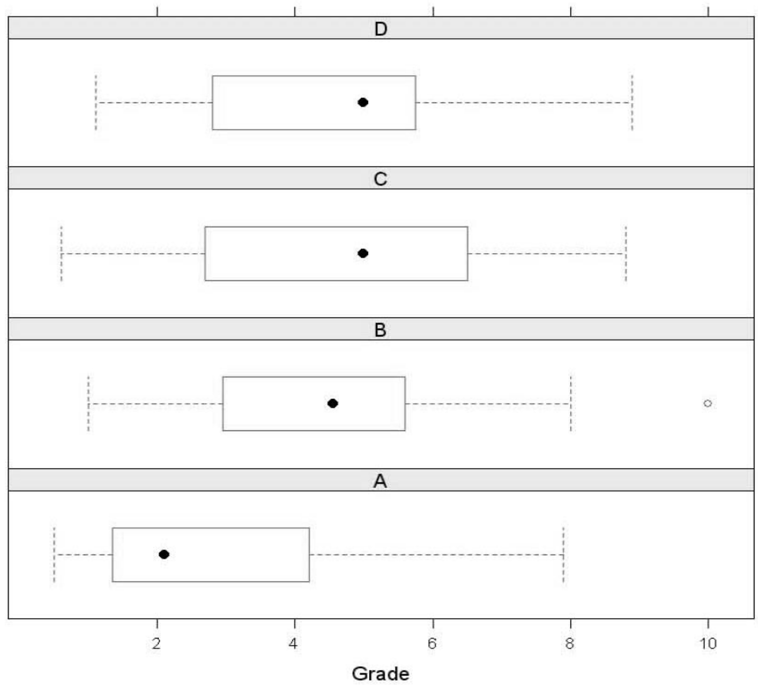

Fig. 1. Boxplot of data.

Table 1. Summary statistics

	Group A	Group B	Group C	Group D
Min	0.500	1.000	0.600	1.100
1st. Qu.	1.375	2.975	2.725	2.800
Median	2.100	4.550	5.000	5.000
Mean	2.892	4.382	4.713	4.472
3^{rd} Qu.	4.150	5.350	6.400	5.750
Max	7.900	10.000	8.800	8.900
NA's	28.00	36.000	18.000	21.000
S.D	1.8867	2.1181	2.1713	1.9139

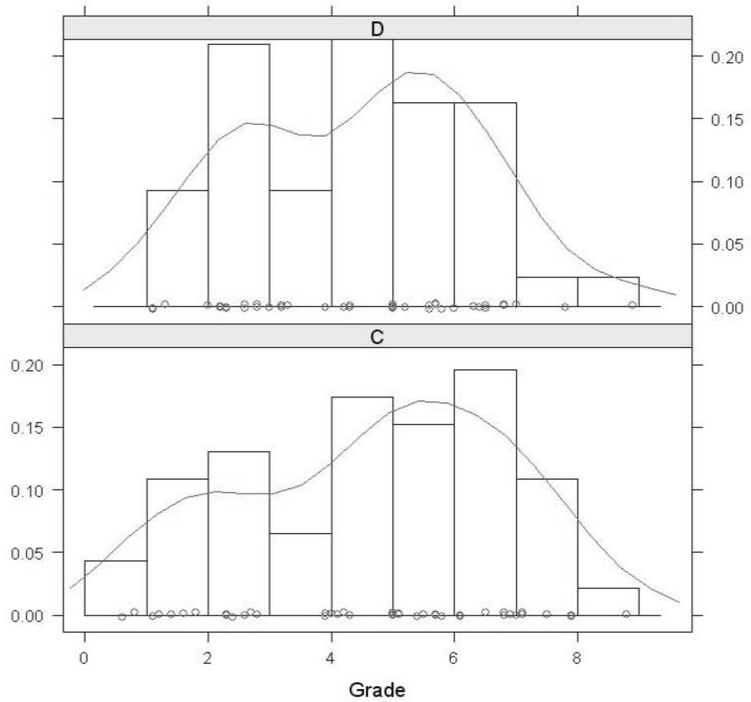

Fig. 2. Histogram and density estimate of the groups C and D.

where

$$S_p^2 = \frac{(n-1)S_X^2 + (m-1)S_Y^2}{n+m-2}\left(\frac{1}{n} + \frac{1}{m}\right)$$

(S_X^2 and S_Y^2 are the sample variances),

will have a $t(n+m-2)$ distribution under the null hypothesis [11].

Normality test statistics and the F-test's equal variances [12] were obtained. The R commands were:

```
>shapiro.test(GroupC)
>shapiro.test(GroupD)
>var.test(values~ind,data=dCD)
```

The Shapiro-Wilk normality test:

```
data: GroupC
W = 0.9579, p-value = 0.09503
```

Shapiro-Wilk normality test:

```
data: GroupD
W = 0.9687, p-value = 0.2856
```

The F- test to compared two variances:

```
data: values by ind
F = 1.2872, num df = 45, denom df = 42, p-value =
0.4114
alternative hypothesis: true ratio of variances is not
equal to 1
95% confidence interval:
0.7023791 2.3440031
sample estimates:
ratio of variances
1.287175
```

Hence, the two samples under analysis had normal distributions with common variances. Then we carried out the two sample t-tests to see if the new method was superior to the current one. The R commands were:

```
>t.test(GroupC,GroupD,alt="two.sided",
var.equal=TRUE)
```

Two sample t-tests:

```
data: GroupC and GroupD
t = 0.5538, df = 87, p-value = 0.5811
alternative hypothesis: true difference in means is not
equal to 0
95% confidence interval:
–0.6238276 1.1057285
sample estimates:
mean of x mean of y
4.713043 4.472093
```

Therefore, for the data under analysis, we have found that the differences between Groups C and D were not significant.

Next, the two teaching methods (SCLS and TTLS) were compared for Groups A and B. Figure 3 shows the histogram and density estimate of the Groups A and B. R commands were:

```
> dAB=stack(list("A"=GroupA,"B"=GroupB))
>histogram(~values|factor(ind),data=dAB,
type="density"xlab='Grade',
ylab=",main=' ',panel=panel.mipanel,layout=c(1,2))
```

Because distributions were strongly skewed (see Figure 3), carrying out the two sample t-test was inaccurate. Furthermore, the data suggested that the grades of Group B may be larger than the grades of Group A.

Now we sought evidence that methodology SCLS increased scores.

Data of grades of Group A and Group B were modeled as realizations of random samples $X_1, \ldots, X_n$ and $Y_1, \ldots, Y_m$, from two distributions, one with expected value μ_1 the other with expected value μ_2. The test of hypothesis was $H_0 : \mu_1 = \mu_2$ against $H_1 : \mu_1 < \mu_2$ at level 0.05. Then, the normality test statistics [12] were obtained. R commands were:

```
> shapiro.test(GroupA)
> shapiro.test(GroupB)
```

Shapiro-Wilk normality test:

```
data: GroupA
W = 0.8973, p-value = 0.002884
```

Shapiro-Wilk normality test:

```
data: GroupB
W = 0.9649, p-value = 0.453
```

If we cannot assume normal model distributions, we cannot conclude that our test statistic has a $t(n + n - 2)$ distribution under the null hypothesis.

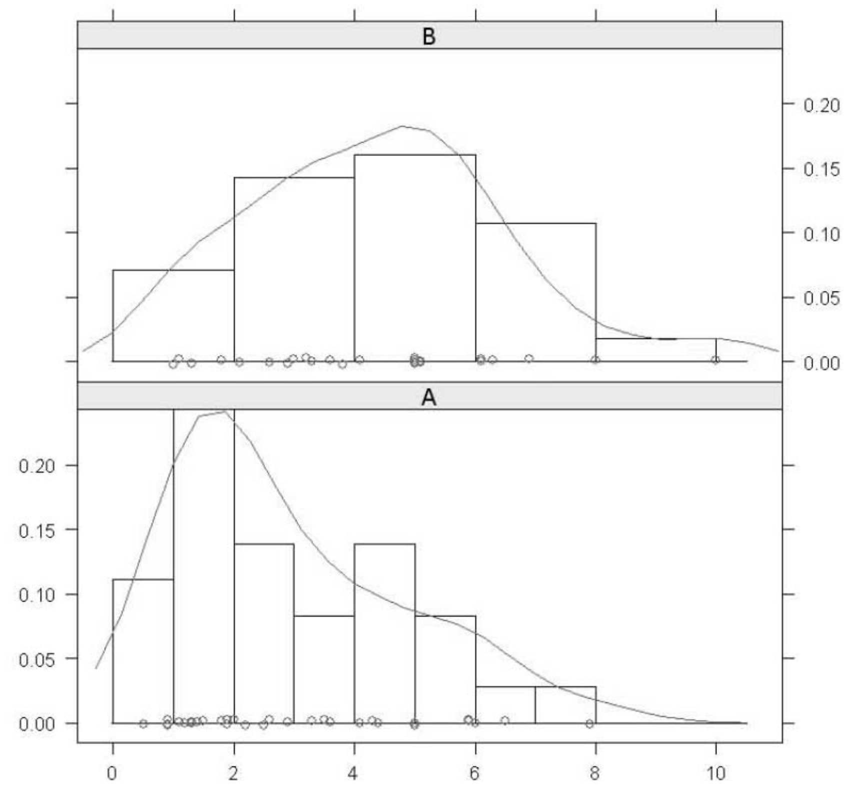

Fig. 3. Histogram and density estimate of groups A and B.

To approximate the distribution, we used the bootstrap method, which, based on many resamples of the observed dataset, represents the sampling distribution of the statistic T.

T-statistics were computed for the bootstrap data and the empirical distribution function of one thousand bootstrap values [11] was found. See Figure 4. The R commands were:

```
>t=NULL
>n=length(GroupA)
>m=length(GroupB)
>for(i in 1:1000){
  x=sample(GroupA,replace=T)
  y=sample(GroupB,replace=T)
  t=c(t,(mean(x)-mean(y)-(mean(GroupA)-
    mean(GroupB)))
  /sqrt(((n-1)*var(x)+(m-1)*var(y))/(n+m-2)*(1/n+1/m)))
                }
>plot(ecdf(t))
>quantile(t,c(0.05))
>statistic=(mean(GroupA)-mean(GroupB))/sqrt
(((n-1)*var(GroupA)+
  (m-1)*var(GroupB))/(n+m-2)*(1/n+1/m))
```

From Figure 4 it can be seen that the data gave good evidence that the new method (SCLS) beat the standard method (TTLS) for the Groups A and B.

Finally, a statistical analysis of the correlation between the average performance of the students of Group C in AC-I and their performance in the 10 compulsory knowledge tests during the semester was made.

To that end, the data set (TestGradeC.txt) was loaded and the variables in the data set (GroupC,Tests) were accessed.

The first step was to make the scatter-plot of the data and find the Pearson correlation coefficient. Figure 5 shows the scatter-plot. R commands were:

```
>plot(Tests,GradeC,xlab="Tests",ylab="Grade")
>cor(GradeC,Tests)
```

In this case, the Pearson correlation coefficient was: r = 0.773555. Then, the data were modeled by using a simple linear regression model [13]. The R commands were:

```
>regression=lm(GradeC~Tests)
>summary(regression)
>residuals=resid(regression)
>Fitted=fitted(regression)
```

Call:
lm(formula = GradeC ~ Tests)

```
Residuals:
  Min       1Q      Median     3Q       Max
-2.0625  -0.9779  -0.3414   0.9710   2.9626
Coefficients:
              Estimate  Std. Error  t value  Pr(>|t|)
(Intercept)   1.2377    0.6149      2.013    0.0526.
Tests         0.9166    0.1327      6.905    8.13e-08***
- - -
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.363 on 32 degrees of freedom
Multiple R-Squared: 0.5984, Adjusted R-squared: 0.5858
F-statistic: 47.68 on 1 and 32 DF, p-value: 8.132e-08
```

Then, the residuals were used to check the adequacy of the fitted model using several plots: a plot of residuals against fitted values and a Normal Q-Q Plot [13]. (See Figure 6). The R commands were:

```
>par(mfrow=c(2,1))
>qqnorm(residuals,main=" ")
>qqline(residuals)
>plot(Fitted,residuals,xlab="Fitted",ylab="Residuals")
>abline(h=0,lty=3)
```

Figure 7 shows the scatter-plot of the data with the estimated regression line $y = 1.23 + 0.91x$ superimposed on it. The R commands were:

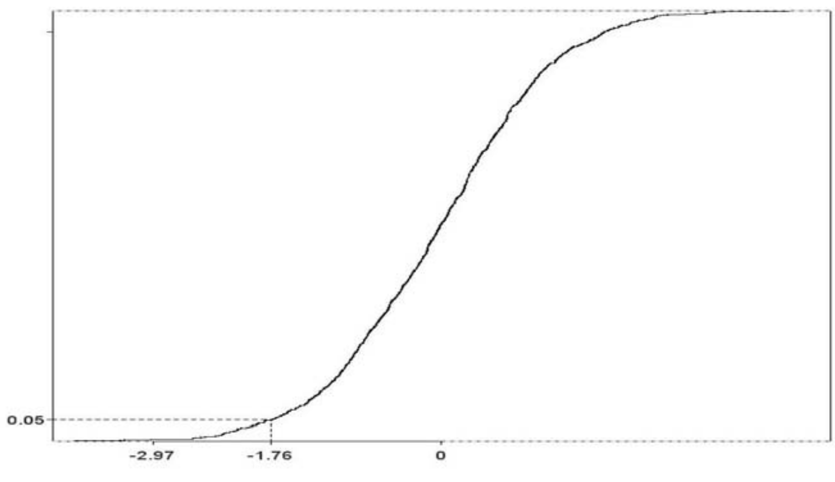

Fig. 4. Empirical distribution of 1,000 bootstrap values.

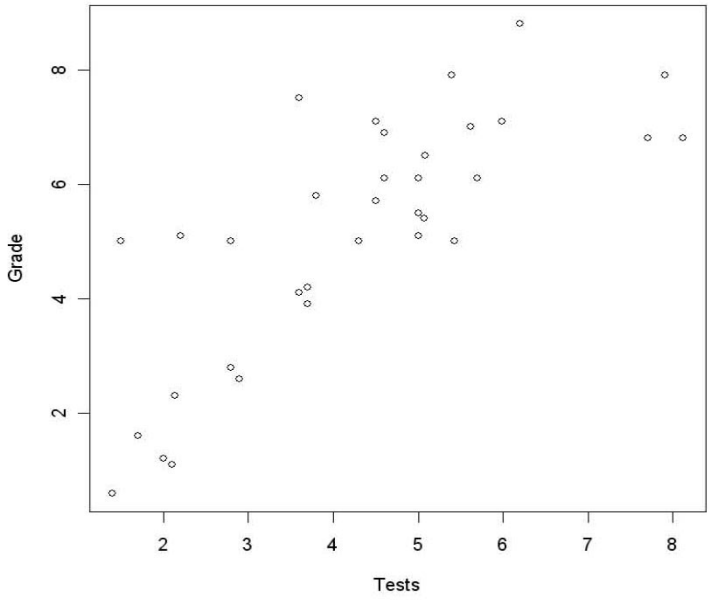

Fig. 5. Scatter-plot of the data.

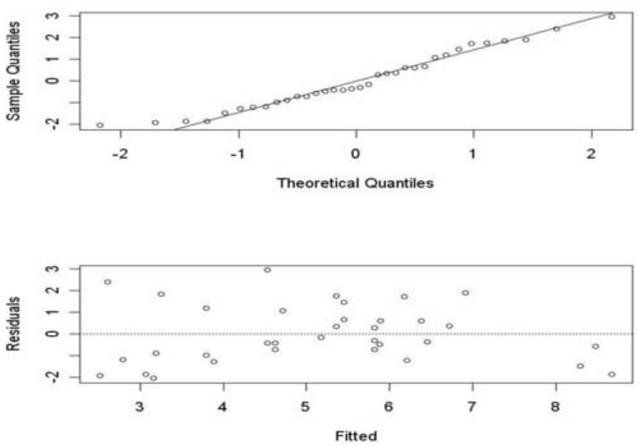

Fig. 6. Residuals versus fitted values plot and Normal Q-Q plot.

```
>plot(Tests,GradeC,xlab="Tests",ylab="Grade",
xlim=c(0,9))
>abline(regresión,lwd=2)
```

From the above analysis it can be seen that results in the 10 knowledge tests were a very good explanation of student performance in the subject AC-I.

RESULTS OF SURVEYS

The overall satisfaction of students and their professors who participated in this educational experiment was quite positive. Their level of satisfaction was high and reactions to the SCLS were positives. However, there is still room for improvement and the continuous feedback from all the participants is needed to improve the teaching and learning system.

Results of the surveys can be summarized as follows:

SCLS has enabled students to understand the areas in which they are having difficulty and to concentrate their efforts in those areas. Students attend more to classes with the SCLS than with the TTLS because they have realized both that they learn more and that they pass the subjects with better final grades. Also, the fact is highly valued that if the performance of any student in AC-I is outstanding, he/she does not have to do the final written exam.

In addition, the use of the VLE is of paramount

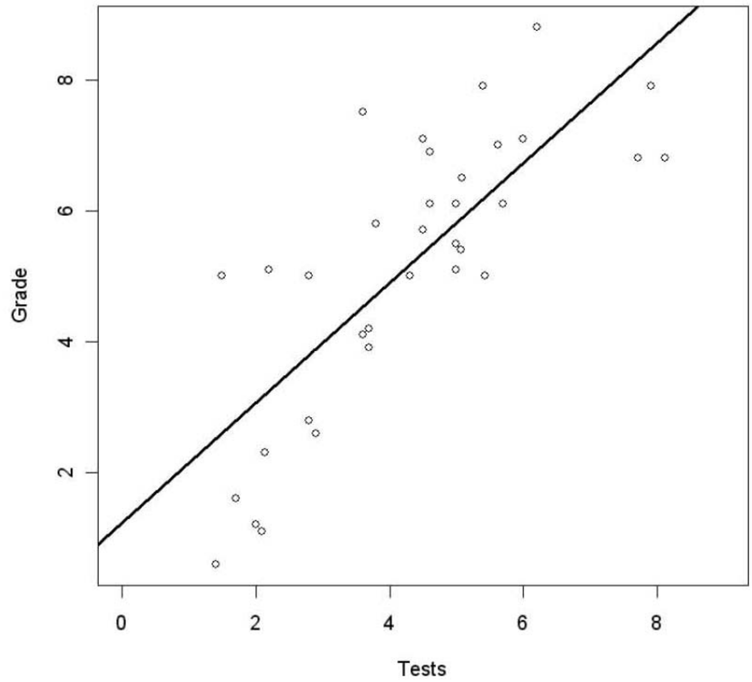

Fig. 7. Scatter-plot of the data with estimated regression line superimposed.

importance for part-time students; the fact that lecture rooms have been designed to facilitate teamwork among students and to make them feel comfortable in classes, is also highly valued [14–15].

Collaborative and cooperative work among participating professors has been very positive. The SCLS allows the professors to carry out better planning of the content of the subjects they teach.

With SCLS, the students feel that the professors are more approachable, available and willing to meet, which makes a great difference in the classroom [7].

Despite the fact that most of the participating students are in favor of SCLS, some of them think that the workload is heavier than in the TTLS. Given this, several students drop-out more than one subject in the middle of the semester. Also, the preparation of the students before entering university should improve, and all the professors of the school should follow the same or a very similar continuous assessment system.

As at the beginning of the semester, professor workload with SCLS is greater than with TTLS, some professors are not totally willing to change the traditional methods of teaching; to improve communication, teamwork and lateral thinking, the amount of interdisciplinary lessons should be increased [16].

Despite there being room for improvement, general conclusions drawn from the comments made by students and professors showed that SCLS is the way to go for NFYS. However, SCLS should be improved taking into consideration the point of view of each student as 'the customer' who has paid for a 'service' that is delivered by the instructor [17].

CONCLUSIONS AND CONSIDERATIONS

The statistical analysis conducted in this paper has shown that the application of SCLS to improve the performance of the NFYS has yielded satisfactory results in subject AC-I. In short, we have shown that the differences between the academic results of NFYS that study under the SCLS (i.e. Group B) and those that study under TTLS (i.e. Group A) are significant.

However, one discovery has been that for students who were taking the subject again (STSA), despite academic results obtained by students with SCLS (i.e. Group C) being better than those obtained by students with TTLS (i.e. Group D), the differences between their academic results were not significant.

These experimental results were very important because they allowed us to see in practice the importance of understanding student differences [18]. In general, STSA do not need so much help as NFYS. STSA are better prepared than NFYS and ready to work harder in order to learn more and to pass the subject with better marks than NFYS. Therefore, the implementation of the SCLS for NFYS should be different from that for STSA.

Finally, it should be pointed out that despite there being still plenty of room for improvement, in the four years we have been involved in many educational experiments in most of the schools at the UPM, performance of the students under different SCLS has generally been better than that with TTLS. With SCLS, students have to work harder than with TTLS but they learn more, pass the subjects with better marks and develop skills that will help them to become good professionals [19].

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APPENDIX: KNOWLEDGE TEST EXAMPLE

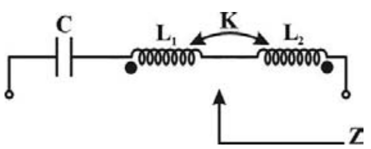
Unit 5: Magnetically coupled circuits

Mark the correct answer.

1. What is the input impedance Z of this circuit?

$$L_1 = 1\text{mH}; L_2 = 2\text{mH}; K = \frac{1}{\sqrt{2}};$$

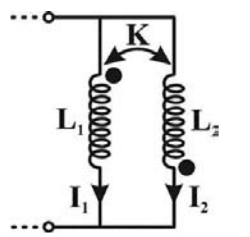
$$C = 1000\mu\text{F}; \omega = 1000\,\text{rad}/\text{s}$$



a) $-\frac{\sqrt{2}}{2}j$
b) 0
c) $j\Omega$
d) $3j\Omega$

2. What is the value of $\frac{I_2}{I_1}$ in this circuit?

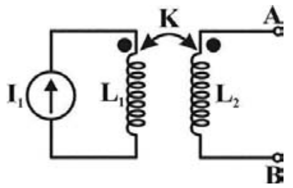
$$\omega L_1 = 2\Omega; \omega L_2 = 8\Omega; K = \frac{1}{2}$$



a) $\frac{1}{4}$
b) $-\frac{1}{4}$
c) $\frac{2}{5}$
d) $-\frac{2}{5}$

3. What is the Norton-equivalent current I_{Th} for this circuit?

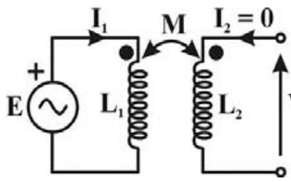
$$I_1 = 6A_{rms}; \omega L_1 = \omega L_2 = 3\Omega; K = \frac{1}{3}$$



a) 0
b) $2A_{rms}$
c) $3A_{rms}$
d) $-3A_{rms}$

4. What is the coupling factor K of this circuit?

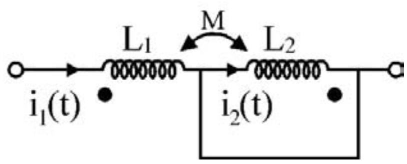
$$\omega L_1 = 9\Omega; \omega L_2 = 7\Omega; |V_2| = 6V_{rms}; |I_1| = 1A_{rms}$$



a) 1.33
b) 0.80
c) 0.76
d) 0.60

5. What is the value of $i_2(t)$ in this circuit?

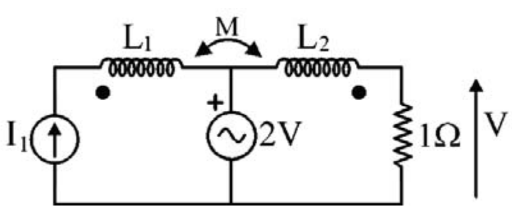
$$\omega L_2 = 3\Omega; \omega M = 2\Omega; i_1(t) = 6 \sin \omega t[A]$$



a) 2sin ωt[A]
b) 4sin ωt[A]
c) 3sin ωt[A]
d) 3sin $(\omega t + \pi)$[A]

6. What is the value of V in this circuit?

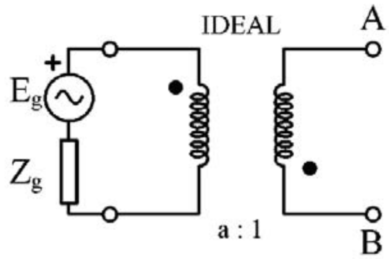
$$\omega L_1 = \omega L_2 = \omega M = 1\Omega; I_1 = 2A_{rms}$$



a) $-jV_{rms}$
b) $1 + jV_{rms}$
c) $2 + j2V_{rms}$
d) $1 - jV_{rms}$

7. What are the Thévenin-equivalent voltage V_{Th} at the output terminals of this circuit and the Thévenin-equivalent impedance measured Z_{Th} across the points A and B looking back into the circuit?

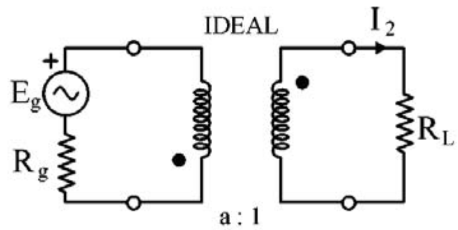
$$a = 2; E_g = 4V_{rms}; Z_g = 4 - j4\Omega$$



a) $V_{Th} = -8V_{rms}; Z_{Th} = 2 + j2\Omega$
b) $V_{Th} = 8V_{rms}; Z_{Th} = 2 - j2\Omega$
c) $V_{Th} = -2V_{rms}; Z_{Th} = 1 - j\Omega$
d) $V_{Th} = 2V_{rms}; Z_{Th} = 1 + j\Omega$

8. What should be the ratio of the number of turns of wire in the primary and the secondary windings of the ideal transformer of this circuit in order to match the source resistance R_g to the load resistance R_L?

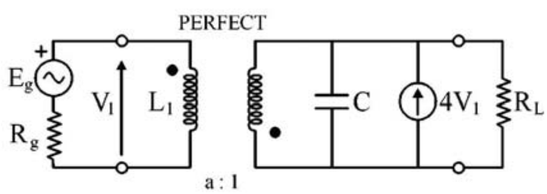
$$E_g = 4V_{rms}; R_g = 4k\Omega; R_L = 1k\Omega$$



a) a = 4
b) a = 3
c) a = 2
d) a = 1

9. What is the power consumption of the current source $4V_1$ in this circuit?

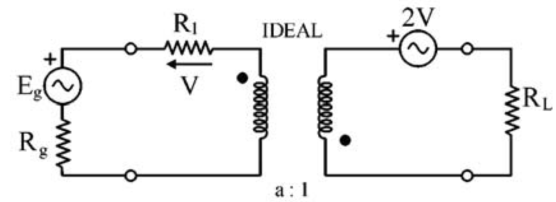
$$E_g = 10 + j10V_{rms}; \omega L_1 = \frac{4}{\omega C};$$
$$a = 2; R_L = 1\Omega; R_g = 4\Omega$$



a) 2W
b) −2W
c) 4W
d) −4W

10. What is the power consumption of the voltage source 2V in this circuit?

$E_g = 20V_{rms}; R_g = 5\Omega; R_L = 2\Omega; R_1 = 1\Omega; a = 2$



a) 8W
b) −4W
c) 16W
d) −18W

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