A comparison of two teaching methods

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Abstract: - We give tha analysis of the data collected during an experience to compare the traditional teaching method with another alternative method in which the pupils received the instruction in these subjects by means of software applications.

The content of this paper is based on a teaching experiment using software in the subjects of Calculus, namely the functions and derivatives, and is elaborated with the data of the project C9548595 of the Polytechnic University of Madrid. The analysis is made by means of elements of Descriptive Statistic, since the sizes of the samples are small, and with data collected before and after the experiments.

Key-Words: - Teaching methods; Computers packages; Exploratory Data Analysis; Graphical Procedures.

1 Presentation

The goal of this paper is to show the analysis of the information collected in an experiment to compare two teaching methods, the current method and an alternative method in which the students received the teaching, exclusively, by means of software tools.

For the experiments four classes of a public school were chosen:

a) 31 students of a class of level school Obligatory Secondary Education fourth grade (4th ESO), between 13 and 14 years old.
b) 33 students of a class of level school High school in Social Sciences first grade (1st B), between 14 and 15 years old.
c) 61 students, 28 and 33 respectively, of two classes of level school High school in Nature and Health Sciences first grade (1st D and1st E), between 14 and 15 years old.

The computer packages that were chosen for the experiences are two Windows compatible applications, developed in Visual Basic with academic objectives: *Study of Functions* (Estudio de Funciones), developed by Villalba [6]; and *The derivative: Concept and Applications* (La derivada: Concepto y Aplicaciones), by Aguirrebeña [1]. The objective of both software packages is that the user acquires concepts and skills in Calculus, dealing in particular with the subjects "Functions" and "Derivatives", respectively.

2 Design of the experiment

The subjects, nomenclature, and examples developed by the software tools were analyzed. We modified and omit some parts, and printed screens of the software, so that the professor of each course imparted the classes according to the software tools.

The students of the grades 4th ESO and 1st B would carry out the practices with the program about "Functions ", and the students of 1st D and 1st E with the program about "Derivatives". As the students were informed of the experience they welcomed it enthusiastically, in general.

The computer laboratory of the public school had ten computers, so the each class was broken down into two groups at random. 10 students formed the experimental group and were taught by means of the new method, the rest being the control group, taught by means of the current method.

Among the data that we gather, and that we will analyze here, are:

a) Average of the qualifications of the exam previous to the realization of the experiment of all the disciplines of the academic program, denoted *Mark average*.
b) The results of an intelligence test model D-70 of Dominoes, which we denote for *Intelligence test*, carried out to compare the students of these grades with the rest of the population their same ages.
c) The results of an individual test on the previous knowledge to the subjects that would be developed in the experiences and that we denote by *Previous knowledge*.
d) At the end of the experiment, all pupils took a standard test whose results are placed in the variable *Final mark*.

The pupils of the experimental groups showed interest for the experience before the start of the

experimental phase, but were thwarted when knew that the teacher's mission in the laboratory was to solve the consultations about the use of the software avoiding the explanations about the mathematical contents of the programs. From the point of view of these students it supposed an unfairness with respect to the other classmates.

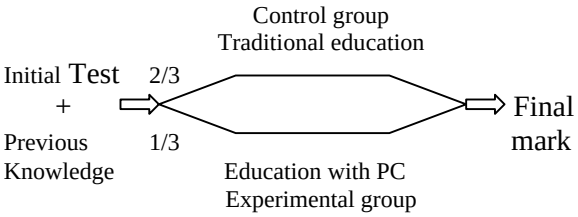

Fig. 1: Diagram of the experiment

3 Statistical analysis of data

Due to the differences among the students that participated in the experience, the analyses have different purposes. First we analyze the three collections of variables before the experiment to detect analogies and differences. Later we compare the marks of the final exam. Also, in 1st B we carry out two additional tests that were also analyzed.

The standard statistical analyses here would usually include multifactor ANOVA, a technique of variance analysis used to examine the effects of two or more factors on one response variable, but in this case we have preferred to carry out an initial examination of data. It is arguable that a more formal analysis is necessary, but it did not seem technically correct, since with such small samples the validity of the assumption that the populations be normally distributed is doubtful.

3.1 Data previous to the experiments

We will analyze the data of the first three variables (*Mark average, Intelligence test* and *Previous knowledge*).

With a preliminary data analysis we observe that there are no significant differences among the four classes, except in the variable *Previous knowledge*. In this variable there is no overlap between observations in classes and the spread of scores is similar among three classes, but in 1st B the scores are lower, and with more spread that in the other classes. Note that this variable is the more subjective.

In the variable *Mark average* we notice that the spread is larger in class 1st D and that in the other three classes there are certain pupils that distinguished. Of the variable *Intelligence test* we will mention the highest concentration in scores of 1st B as well as two individuals whose scores have certain tendency to rise inside this class, and that the variability is of different sign in the classes 1st D and 1st E. Figure 2 provides arguments to obtain the mentioned conclusions.

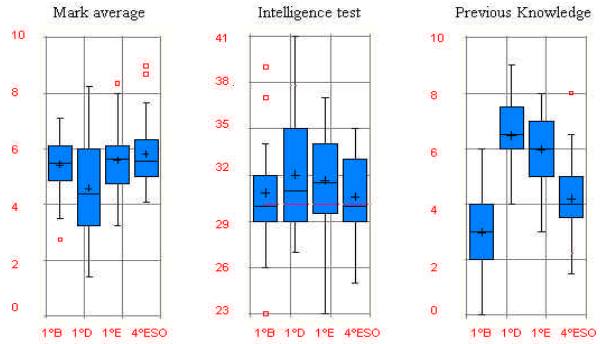

Fig. 2: Box plots of the data

After the pupils of each class are placed in the two groups, the variables are compared to contrast if the distributions in both groups were similar. In Figure 3 the box plots of the variables for classes and groups are shown.

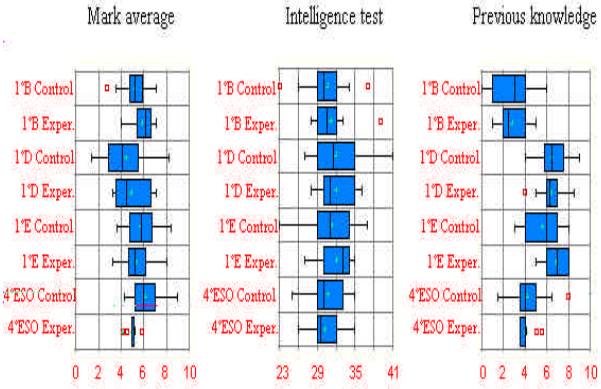

Fig. 3: Box plots of the data in each group

It was then obvious that there was little or no association between the variables and the group, control or experimental. However, in the class 4th ESO the conclusions are not the same, since the distributions of *Mark average* and *Previous knowledge* present a high concentration in the scores of the experimental group.

3.2 Final marks

This is the last variable collected to compare the two teaching styles. The study is carried out with the scores of a different exam in each class, and then it was possible that the distributions of the scores in each course were not same. Other teachers elaborated

the exams of each class, to avoid the teacher's subjective influence.

In Table 1 we show statistical information about the center and spread of the variable.

Class	Group	N	Average	Median	Std. deviation
1st B	Control	23	4.54	5.10	2.06
1st B	Exper.	10	3.76	3.95	1.91
1st D	Control	18	6.33	7.00	1.85
1st D	Exper.	10	5.70	5.50	2.11
1st E	Control	23	5.63	6.00	1.99
1st E	Exper.	10	4.50	5.00	1.84
4st ESO	Control	22	3.27	3.00	1.91
4st ESO	Exper.	9	2.67	2.00	1.73

Table 1: Summary statistics for *Final mark* in classes and groups

With the purpose of eliminating the effects of some factors that intervene on the variable *Final mark* (software, teacher, educational level, etc.) we consider the variable in each class in the first place (see Figure 4).

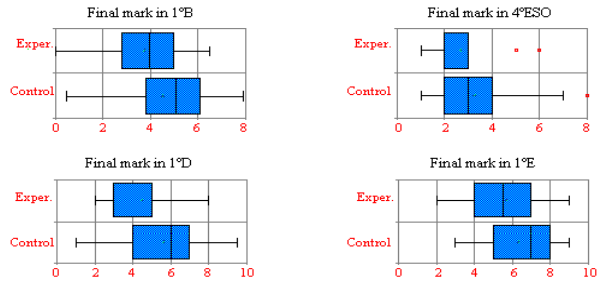

Fig. 4: Box plots for *Final mark* in classes

In the graphics we note that:

a) The control and experimental groups have similar distributions in spread and forms, but the center of the distributions in the control groups is higher than the center in the experimental groups.
b) The control groups have similar spreads, more concentrated in 1st E and less in 1st D. The experimental groups also have similar dispersions, more concentrated in 4th ESO.
c) In the experimental group of 4th ESO the data are very concentrated around the central values and two outliers appear, which are the same as in the variables ***Mark average*** and ***Previous knowledge.***

In the four classes a tendency exists to have lower scores in the experimental group. But when we use methods of analysis of the variance, for each class, comparing the two teaching methods, we conclude that there is not a statistically significant difference between the means, the medians and the standard deviations of the two groups at the 95% confidence level.

To complete the study we consider the set of all the final marks, observing that the distribution is asymmetric and approximately normally distributed, with scores concentrated on central values. In Figure 5, we see a slight tendency for the control group to have a higher score in the exam.

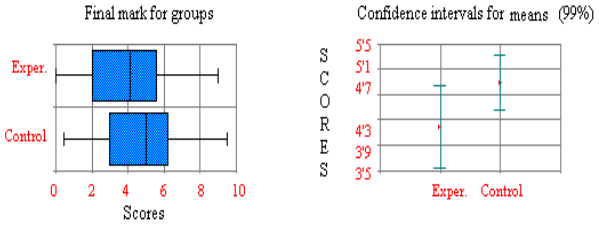

Fig. 5: Box plots and 99% confidence intervals for the means of *Final marks* in each group

Distributions of data in each group can be adequately modeled by a normal distribution, although we have already mentioned that many other factors exist that affect the variable. We use several tests to determine whether there are statistically significant differences between the two groups, and we verify that the means, the medians and the standard deviations of the two groups were not statistically different at the 95% confidence level.

Thus we conclude that there is a not statistically significant difference between the distributions of the *Final marks* of the control and experimental groups, although scores of the experimental group are slightly inferior.

3.3 Additional tests

In 1st B two additional tests were designed, to be carried out after the traditional exam. One of the tests with questions of "True/False" type and the other test had questions with four possible answers each one. The reason of including this type of tests is that the computer applications used by the students of the experimental groups contain annexes where questions appear in terms of "True/False" and with different answering possibilities.

Next, we present a table with a summary statistical (Table 2) and box plot for the control and experimental groups, of multi-answer and True / False exam (see Figure 6).

Exam	Group	N	Average	Median	Std. Deviation
Multi-ans.	Control	23	4.58	4.66	2.45
Multi-ans.	Exper.	9	4.51	4.66	1.90
True/ False	Control	23	3.56	4.00	1.88
True/ False	Exper.	9	4.67	5.50	1.09

Table 2: Summary statistics for *additional test* in Groups

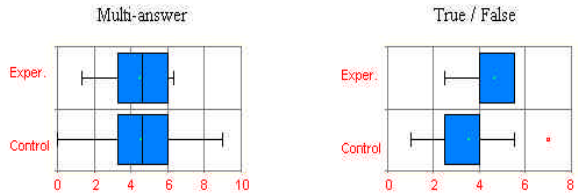

Fig. 6: Box plot for the control and experimental groups of *additional test*

In the multi-answer exam, the only noticeable difference between the two groups is that the scores of the experimental group are more concentrated than in the control group. But in the "True / False" exam we note that scores of the control group are inferior to those of the experimental group. A lack of symmetry and bigger concentration in the scores of the experimental group is also observed.

4 Conclusions

There are differences between the four classes that participated in the experiment such as the educational level, software used, teacher, or questions of the last test, that affect to the global results of the analysis.

Among the pupils of the classes that participated in the experience there are appreciable differences with regard to the variables *Mark average* and *Previous knowledge*, while the differences are slight in *Intelligence test*.

In 1st B, 1st D and 1st E there are no apparent differences between the distribution of data in control and experimental groups for the initial variables. Data of *Mark average* and *Previous knowledge* are very similar in the experimental group of 4th ESO. Therefore, the spread is small and the distributions of these variables seem different between the control and experimental groups of that class.

There is not a statistically significant difference between the *Final marks* of the control and experimental groups, although in the control groups the marks are moderately higher.

But we should underline two circumstances that are not reflected in the data. The first is that many students of the experimental groups occupied great part of their time copying in their notebooks the information shown in the screens of the programs. And the second is that these students were worried about the possibility of loosing the whole academic course due to the experience and, although they were reassured that this was not to take place, they increased the time dedicated to the study of the subjects treated.

In the "True/False" test carried out in 1st B, the scores of the control group were slightly lower, while in the multi-answer test, the distribution of the scores were very similar in both groups.

The teaching method presented here is not intended to be better than the current method, since firstly we would need to decide what we mean by better and how to measure this construct. But this alternative method of mathematical instruction is an effective support for comprehension gained actively, that is consistent with the current recommendations in mathematical education.

It can be investigated on the long-term effect in a curriculum that includes the directed use of this type of software tools, without substituting the professor's figure completely, to document new teaching possibilities.

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