

A Statistical Assessment of an Experiment To Compare Traditional vs. Laboratory Approach In Teaching Introductory Computer Programming

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ABSTRACT

During the Spring of 1995 a statistical experiment to assess the effects of two methods of teaching introduction to Computer programming concepts, was developed. The experiment implemented two teaching approaches: traditional lecture vs. laboratory (technology). Several performance measures were defined and then collected throughout the course, to assess student learning. Among them are: results from common tests, quizzes and homework/projects. In this paper we assess, the effects of these two teaching approaches on students' learning, retention and success rates. We analyze statistically the data collected, testing several hypotheses based on our teaching experience. Finally, we give several conclusions drawn on the analyses results.

INTRODUCTION.

In the Spring of 1995, two sections of MCS 186 (Introduction to Pascal Programming) were offered by the Mathematics department. One section was scheduled with a mandatory laboratory component of 75 minutes per week and the other section was scheduled without this laboratory component. Of course, students chose the section they preferred. Dr. Romeu agreed to teach the non laboratory section and Dr. Alemzadeh agreed to conduct the laboratory section.

Both instructors agreed to follow a common syllabus for the course and to measure their students learning levels through: (1) Ten common pop quizzes (weight 10%); (2) ten laboratory assignments or homeworks (weight 15%); (3) two common pre-final tests (weight 30%); (4) three programming projects (weight 12.25%); (5) a common programming

project (weight 2.75%); (6) a common final test (weight 30%). All evaluations were simultaneously given.

Sixteen students initially registered in the section having a laboratory component and 21 students registered in the traditional section of MCS 186. Ten students completed the laboratory section course work and twelve students completed the traditional section. In the Laboratory section, one student failed the course and in the Traditional section, two students did. The retention rates for the laboratory and the Traditional approaches were 63% and 67% respectively. The success rates for the Laboratory and the Traditional sections were 90% and 81 % respectively.

The following hypotheses (and its reasons) were developed to be compared by these two methods:

1. Students' performance in programming development, for those in the laboratory approach, will be higher than the ones in the Traditional section (due to the practical technology lab influence).
2. Students' grade dispersion (variance), for those in the Laboratory approach, will be smaller than the grade dispersion in the traditional one (due to the intense mandatory Lab work).
3. Students' motivation levels, for those in the laboratory approach, will be higher than those in the traditional section (due to extra work involved).
4. Students' performance in the unannounced quizzes, for those in the Laboratory approach, will be higher than those in the Lecturing section (due to the Lab's extra exposure to the material).
5. Students' independent work quality will be higher, for those in the traditional approach, than for those in the Laboratory section (due to the independence fostered by lack of Lab instructor supervision).

The validity of these hypotheses were tested through statistical analyses of the data collected from this experiment.

DATA.

Statistical analyses was performed on the students' final grades in the course as well as on the results of their performances in the pre-final tests, the final test, the final project, and the pop quizzes. The summary statistics for the collected data for these analyses are given in Table 1. The statistical results of these analyses are given in Table 2. In these tables, FGJAL, TQJAL, PRJAL, T1JAL, T2JAL, FINJAL represent the final grades, total quizzes, project, test1, test2, and final exam grade for the laboratory section. Variables FGJR, TQJR, PRJR, T1JR, T2JR, FINJR represent the final grades, total quizzes, project, test1, test2, and final exam grade for the traditional section.

Table 1.- Descriptive Statistics

Variable	Mean	Std.Dev	Median	Quartile1	Quartile3
FGJAL	2.27	1.26	2.70	0.92	3.30
FGJR	2.77	0.68	2.70	2.07	3.30
TQJAL	2.23	1.16	2.30	1.52	3.40
TQJR	2.07	1.01	1.85	1.40	3.20
PRJAL	3.26	1.37	3.65	2.70	4.30
PRJR	4.04	0.36	4.00	4.00	4.30
T1JAL	1.72	1.14	1.85	0.97	2.55
T1JR	2.90	1.10	3.30	2.07	2.92
T2JAL	2.75	1.39	2.70	1.27	3.17
T2JR	2.46	0.97	2.15	1.77	3.52
FINJAL	1.71	1.14	2.00	0.52	2.70
FINJR	1.52	1.16	1.30	0.77	2.00

ANALYSIS

To statistically assess the performance of these two teaching methods, we compared the results of the two sections. The first one (control) was taught via the traditional lecture (denoted by JR) and the second one (treatment) via the new laboratory approach (denoted JAL). We denoted the results from the variables: Final Grade (FG), Total Quiz work (TQ), the last Programming Project (PR), the First Test (T1), the Second Test (T2) and the Final Exam (FIN) for each section. These analyses results are presented in Table 2.

We looked into, both, the behavior of central tendency and of dispersion, for the performance measures analyzed. We used two statistical methods for the comparison of measures of central tendency between two samples: the t-test and the Wilcoxon-Mann-Whitney test. The first one compares the population means, but requires that the data are normally distributed. We did not want to impose such a strong assumption on our data, given the small sample sizes and the shapes of their histograms. So we relied on the results of the second test, which compares the median of two populations, but is distribution-free. The results of the Wilcoxon-Mann-Whitney test are also presented in Table 2.

We can see from Table 2, that the only statistical difference established, at a significance level of 0.05, is between the grades of the First Intrasegmental Exam (T1JAL vs. T1JR). In this case, the traditional method yielded a significantly higher median score grade than the laboratory approach. Perhaps, the students required some lead time to adapt to this (technology based) teaching method. The rest of the variables compared, don't yield significantly different measures of central tendency

(median or mean), via any of the two statistical procedures above mentioned, used to test them.

We did find, however, that in the cases of variables Final Grade (FG) and Programming Project (PR), the variances of the grades from the two groups were significantly different. We thus proceeded to test the hypothesis that these two group grades had the same variance, using the traditional F-Test for two samples. The results are also shown in Table 2.

In both of these comparisons (FGJAL Vs FGJR and PRJAL Vs PRJR) we detected a statistical difference between the two population variances, at a significance level of 0.05. In both cases, the smaller variance corresponded to the Traditional Lecture. Since the variance is a measure of dispersion, these results can be interpreted as saying that, in the Traditional approach, student grades were more homogeneous.

Finally, by inspecting the descriptive statistics presented in Table 1, we corroborate the above mentioned dispersion results. The Interquartile Range (Upper minus Lower quartiles) for the variables Final Grade (FG) and Programming Project (PR) results also show the largest differences, among all pairs of variables compared.

Table 2.- Statistical Test Results

TREATMENT	TEST	RESULTS
FGJAL VS. FGJR	MEDIAN	NONSIGNIFICANT
TQJAL VS. TQJR	MEDIAN	NONSIGNIFICANT
PRJAL VS. PRJJR	MEDIAN	NONSIGNIFICANT
T1JAL VS. T1JR	MEDIAN	SIGNIFICANT
T2JAL VS. T2JR	MEDIAN	NONSIGNIFICANT
FINJAL VS. FINJR	MEDIAN	NONSIGNIFICANT
PRJAL VS. PRJR	VARIANCE	SIGNIFICANT
FINJAL VS. FINJR	VARIANCE	SIGNIFICANT

ONGOING EXPERIMENT

In the Spring of 1996, again two sections of the MCS 186 Course were offered by the Mathematics department. Again, one section was scheduled with a mandatory laboratory component for 75 minutes per week and the other section was scheduled without laboratory component. Students again chose the section they preferred. Dr. Romeu conducted the traditional section and Dr. Alemzadeh conducted the laboratory section. Thirteen students registered in the section with laboratory component and 16 students registered in the traditional section. Both instructors followed

a common syllabus for the course and measured their students' learning levels in the same way as they did in the Spring of 1995. Data analyses for this second experience are in the works. Preliminary results are similar to the ones obtained in 1995.

CONCLUSION

In the present experiment we collected and analyzed data to assess student learning through the following five hypotheses: (i) Student performance in the course, measured by their grades in the final test, is the same for both approaches; (ii) student spread in performance, measured by the variances in their final grades, is the same for both approaches; (iii) student performance, in hourly tests, is the same for both approaches; (iv) student performance in unannounced quizzes is the same for both approaches; (v) student independent work, measured by their grades in the final project, is similar for both approaches.

Based on the data in Table 1, it appears that, Laboratory students' performance in the first test was below that of Traditional students. However, their performance in the remaining course tests was above the performance of the students in the Traditional group. Also, from Table 1, we can say that, the performance of Laboratory students, in the unannounced quizzes appears to be higher than that of students in the Traditional section. However, the only statistically significant difference established corresponds to grades in the first test. The statistical tests in Table 2 do not indicate that the independent work quality of the students in the Traditional Lecture section, as measured by the final programming project (PR) results, differ from that of the students in the Laboratory section. In our initial hypotheses, we assumed these students would do better than Laboratory students, due to their more independent working guidelines. This failed to materialize.

Also, from the statistical tests reported in Table 2, variances from the Programming Projects (PR) and the Final Grade (FG) grades, from the Traditional Lecture students, are smaller than those of the Laboratory Section. We conjecture whether Laboratory approach work, providing more guidance, is more individual. And that students in the Traditional Section, with less guidance, have to rely more on each other thus learning more from each other.

The data analysis did not provide conclusive evidence regarding a clear difference between the two section results: for Pop Quizzes nor for the overall Final Grades. There is only anecdotal evidence (such as student comments and retention percents) to support that some types of students

do better with the Laboratory approach and some do better with the Traditional lecture approach. Further research in this area is suggested.

The results reported in this paper and in CIT 94 and CIT 95 Proceedings, regarding the assessment of the effectiveness of teaching programming concepts through Laboratory approach, are encouraging. However, it is premature, just by looking at the results of these two groups, to draw a definitive conclusion about one being superior to the other. We are hoping to draw more solid conclusions about the effectiveness of teaching through Laboratory approach, after analyzing the data, from the two 1996 groups.

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