CONTRIBUTION OF LEARNING STATISTICS AT SECONDARY SCHOOL TO STUDENTS' RESULTS AT UNIVERSITY

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This study concentrates on the analysis of responses to a questionnaire given to a sample of University Students in Portugal that concerns the teaching/learning of Statistics and Data Analysis. We first focus on the effectiveness of teaching Quantitative Methods at secondary level as regards increasing performance in the Introductory Statistical Course (ISC) at University level. The second question is related to the students' feelings towards Mathematics and whether these feelings imply a difference in students' performance on statistics. Even when results cannot be generalised, since the study is limited to our context, the data analysed suggest the need to rethink the goals of teaching statistics at secondary school level, at least in our context.

INTRODUCTION

Students in Portugal now can either take Mathematics or Quantitative Methods (QM) at secondary school. It is important that this topic is used to introduce elementary concepts of descriptive statistics as a way to increase students' interest in pursuing other statistics courses at University level.

This introduction involves some problems. For example, it is known that the community of teachers and researchers in Statistics education is very heterogeneous (Batanero, 2002), since the teaching/learning of QM is related to various basic background branches (Mathematics, Engineering, Economics, Psychology, etc). Additionally, the use of new technologies in the teaching/learning of Statistics and Data Analysis is currently increasing in this technological information and communication society (Vallecillos and Moreno, 2002). An additional factor that affects learning performance is how students face knowledge, and this includes their attitudes towards the topic. Attitudes as intensive feelings, relatively stable, are consequence of positive or negative experiences over time in learning a topic (in this case Statistics) (Estrada, 2002).

The aim of this study is testing a working hypothesis, which states that the teaching/learning of QM at secondary level is useful to obtain more effective results on the teaching/learning of Statistics at University. Without aiming to present a final balance on the effect of taking a QM course in secondary school we want to present some data to promote reflection on the topic.

METHODOLOGY

To confirm this hypothesis, we gave a questionnaire to a group of 136 students taken at random from those at the Instituto Superior de Ciências Sociais e Políticas (ISCSP) of the Universidade Técnica de Lisboa (UTL), who were taking the Introductory Statistics Course (ISC) at the Faculties of Sociology and Social Communication. All of them had similar learning conditions in the ISC course and the same teacher. Part of them studied Mathematics and the others took QM at secondary level.

We wanted to check if the introduction of QM at secondary level is valuable for other disciplines of the area at University. The distribution of QM scoring results of those students taking QM in secondary school is presented (Figure 1) and it suggests good learning (in a scale 0-very poor to 20-excellent, the average is over 14.7).

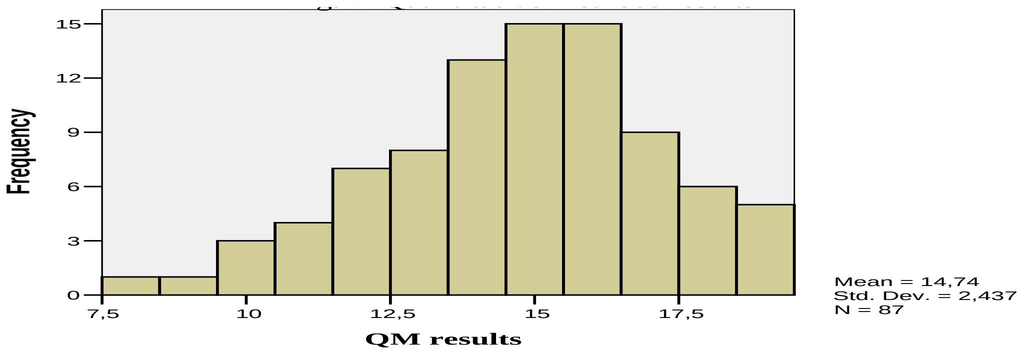

Figure 1: Quantitative methods results

The questions given to the students were: a) Whether they liked Mathematics or not; b) Whether they took Mathematics or QM at secondary school. We also collected their final scores in the Introductory Statistics Course as well as their scoring in either Mathematics or QM in secondary school. Data analysis was based on some parametric and non-parametric hypothesis tests, following the models of Bernardo (2005), Levene (1960), Mann-Whitney (1947), Lilliefors (1967), as well as some correlations (Ahlgren, Jarneving, and Rousseau, 2003). Below we describe these analyses and present the results.

DATA ANALYSIS AND RESULTS

Relating affection and Results in the Introductory Statistics Course

A preliminary data analysis (Cross tabulation of *Affection* (Liking or disliking Mathematics) and *scoring results* in the ISC (passed, failed or not taking the assessment)) showed similar percentages of students liking (50.7%) and disliking (49.3%) Mathematics in the whole sample. Note, 51.5 % of students did not take the final assessment in the ISC. From those who like Mathematics, 46.4% had passed, and the same happens with only 31.3% from those who do not like Mathematics. Consequently, we found some traces that indicate that students liking Mathematics tend to have better results in the Introductory Statistics Course.

			ISC results			
			without assessment	failed	passed	Total
Like Maths	no	Count	42	4	21	67
		% within Like Maths	62,7%	6,0%	31,3%	100,0%
	yes	Count	28	9	32	69
		% within Like Maths	40,6%	13,0%	46,4%	100,0%
Total		Count	70	13	53	136
		% within Like Maths	51,5%	9,6%	39,0%	100,0%

Figure 2: Affection vs results in the introductory statistics course

Relating Affection and Results in Secondary Mathematics

In relation to our main purpose we analysed the mean score in Mathematics at secondary school level of those students who took Mathematics, in relation to affection (estimates for students liking or disliking mathematics were 15.24, and 13.17, respectively). So, to test $H_0 : \mu_{M / Like\,M} \leq \mu_{M / Dislike\,M}$ vs. $H_1 : \mu_{M / Like\,M} > \mu_{M / Dislike\,M}$, we firstly applied the Levene's (Levene, 1960) test for equality of variances, and did not reject the null hypothesis, because the p-value (0.568) was bigger than α (the evidence against the null hypothesis of homocedasticity was weak).

The Kolmogorov-Smirnov normality test (Lilliefors, 1967, Mininni, 1999), resulted in a p-value of 0.2 (for those who disliked Mathematics), and 0.074 (for those who liked Mathematics), and then, the evidence against the null hypothesis of normality was weak, and we did not reject the null hypothesis.

Basing on these conclusions, we did a *t*-test for equality of means, and since the p-value was 0.009 we rejected H_0. So, we can say the mean of students' Mathematics scores was bigger for the students that liked Mathematics. This suggests that the increase affection of students for Mathematics tend to a good experience in learning Mathematics (and good results).

Differences in Mathematics vs. Quantitative Methods

Another question was to study the difference between the means scores of students, on Mathematics and MQ, at secondary level. We tested the hypothesis $H_0 : \mu_{MQ} \leq \mu_M$ *vs.* $H_1 : \mu_{MQ} > \mu_M$, with estimates, 10.06 and 14.74, for Mathematics and MQ, respectively.

The p-value for Levene's test is 0.520, and so there was no evidence to reject the null hypothesis; in the Kolmogorov-Smirnov test we found a p-values of 0.003 (Mathematics) and 0.005 (QM), so we rejected the null hypothesis and accepted the alternative hypothesis; we concluded for non normality for both Mathematics and QM scoring results.

Consequently, the *t*-test that presupposes a normal distribution is inappropriate. For this reason we used the Mann-Whitney test (Mann-Whitney, 1947), which gave a p-value close to zero, and we concluded by rejecting the null hypothesis, and accepting the alternative (the QM mean is greater than the Mathematics mean, at secondary level). Our results suggested better scoring in QM than in Mathematics at secondary school level.

Relating Results in Secondary School QM and in the University

The previous results lead us to the hypothesis that students who did QM at secondary school would perform better on Statistics than students who took Mathematics.

To check this assumption we test the hypothesis that the Statistics mean score was greater when the students coming from QM, that is, $H_0 : \mu_{Stat/QM} \leq \mu_{Stat/M}$ *vs.* $H_1 : \mu_{Stat/QM} > \mu_{Stat/M}$ (the estimates were 12.09 for Mathematics, and 11.64 for QM).

The p-value for the Levene's test for equality of variances was 0.927; so we accepted the null hypothesis of equality of variances; the p-value for Kolmogorov-Smirnov test was 0.007, hence the data provide sufficient evidence against normality of Quantitative Methods scores. We then used the Mann-Whitney test, without making distributional assumptions. The p-value (0.605) was bigger than any α, and we did not have evidence to reject the null hypothesis. Therefore, we concluded that the teaching/learning of Quantitative Methods on the secondary level does not lead to better scores on Statistics at the University.

From another point of view, we correlated the Statistics scores with the QM and Mathematics scores, and obtained 0.105 and 0.425, respectively. Then, we saw that the Statistics scores were more correlated with Mathematics ones, than with QM. Therefore, our study suggests that, contrary to our expectation, secondary school Mathematics tend to better prepare our students for the Introductory Statistics Course than secondary QM.

Relating Affection and ISC Results

Finally, we tested the effect of Mathematics affection on Statistics results (The means estimates are 11.56, and 11.68, for students disliking and liking Mathematics, respectively).

To test $H_0 : \mu_{Stat/Like\,M} = \mu_{Stat/Dislike\,M}$ *vs.* $H_1 : \mu_{Stat/Like\,M} \neq \mu_{Stat/Dislike\,M}$, the Levene's test showed homocedasticity (p-value= 0.156), and the Kolmogorov-Smirnov non normality (p-value close to 0, for both groups).

The Mann-Whitney test gave a p-value of 0.7, and we concluded that there was no evidence to reject the null hypothesis. Affection towards Mathematics did not affect Statistics scores.

CONCLUSIONS

The data analysed led us to make some conclusions. We firstly realised that a good scoring in Quantitative Methods at secondary level is not always a good indicator for good results in the Introductory Statistics at University, even when QM scores results are better than

Mathematics scores results on average. Moreover, at the Introductory Statistics University course, the mean results of students who took QM in secondary school are not greater than those who took Mathematics. Finally even if we found a difference in mean scores in Mathematics, at secondary level, in students who liked or disliked Mathematics, we found no difference in the University ISC course. All these results force us to reflect on the teaching of Statistics at both secondary and University level.

The teaching/learning of Statistics, at ISCSP, is based on the use of computers and *SPSS* software, except for probabilities and distributions. Educational technology provides us a greater variety of strategies for teaching/learning statistics (Godino, Ruiz, Roa, Pareja, and Recio, 2002). However, many students approach information technology as a “necessary evil,” or at least as a required tool that is difficult to use (Dougherty, Kock, Sandas, and Aiken, 2002). As suggested by these authors we should revisit use of technology; it would drastically change the teaching style and the learning style. Teachers are no longer only presenters of information, and so students are no longer only receivers of information. The educational process in both the theoretical and the practical side should became very interactive: There have been made alterations in both education technology and education reform, and so teaching Statistics should encourage students activity, stimulate and guide students learning by personal interaction. A balance is sought to provide a relatively gentle introduction to information technology concepts, yet permit active and discovery types of learning. In this sense we also agree with Watson (2001), that information technology must not only be perceived as a catalyst for change, but also lead to a change in teaching style, change in learning approaches, and change in access to information.

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