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Factors Related to the Academic Performance of Students in the Statistics Course in Psychology

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Abstract. Many studies have examined the factors that influence academic performance in primary and secondary education as well as at university, with the purpose of enhancing learning at these stages and reducing drop-out rates. It is within this research framework that we want to emphasise the deficient performance of students enrolled on the statistics course in the Faculty of Psychology at the University of Barcelona. Consequently, this paper attempts to determine the factors that affect student performance in this subject by undertaking an analysis of a structural equation model and determining its stability over time. In order to accomplish our objective, we worked with two samples of students enrolled statistics classes. The first group comprised 211 students enrolled in the academic year 2000–2001, while the second comprised 287 students enrolled in the academic year 2001–2002. By administering a questionnaire, we obtained information concerning such variables as demographic data, previous academic record, information related to the subject and the degree of satisfaction with it, and the final mark obtained by the students in the subject. The parameters for each group of students were estimated separately and the goodness of fit of the proposed structural model was assessed. The data analysis showed a good fit with both data bases, but the set of estimated parameters differed in the two academic years under consideration.

Key words: academic performance, statistics, structural models.

1. Introduction

The difficulties encountered by psychology undergraduates in learning the contents of the subject of statistics are well known in psychology faculties, and among the lecturers of this subject, throughout Spain. We believe

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these difficulties are caused by two main factors: first, the great differences encountered in the academic backgrounds of the new undergraduates on being admitted to the university, especially in recent years following the introduction of the educational reform act known as the *Ley de Ordenación General del Sistema Educativo* (LOGSE) and, second, and directly linked to this first factor, the fact that first-year undergraduates do not expect to find a subject based on mathematics on the psychology curriculum. Indeed, given these circumstances, it might be the case that not all the first-year students in the Faculties of Psychology possess the academic pre-requisites to cope successfully with the demands of the subject of statistics, which in the case of the Psychology faculty of the University of Barcelona is entitled *Anàlisi de Dades en Psicologia* (Data Analysis in Psychology).

Various attempts have been made to improve the performance of the students enrolled on this subject. Since the academic year 1999–2000, the faculty has introduced an optional subject to raise the level of those whose mathematics skills are insufficient, known as *Fonaments Matemàtics* (Basic Mathematics), specifically designed for those students with little training in mathematics in their pre-university courses in which the presence of mathematics is negligible (Arts and Humanities, for example). Furthermore, and forming part of the framework of pedagogic research which we seek to promote, a number of empirical studies have been undertaken in an attempt to determine the factors influencing student performance in this subject (Barrios et al., 2000; Guàrdia et al., 2002; Peró et al., 2002). This paper can be considered as a continuation of these previous studies and, at the same time, as an attempt to provide a summary of contributions reporting empirical evidence over the last few years concerning the factors influencing academic performance in statistics.

The first question to undertake, and a vital element in any discussion of the academic performance of students at whatever stage of their education, is just how we might define academic performance and, similarly, determine which indicators can be used in its measurement (Gabinet d'Orientació Universitària, 2000a, b). In general, the question of academic performance has been posed as a global question and has usually been the object of very broad, general proposals as well as of theoretical models concerning its conceptual definition (Loeb, 1994; Liljander, 1998). However, the aim we set here has meant that we must centre our analysis on aspects linked more specifically with the characteristics of the subject of statistics. Various studies have been undertaken in primary, secondary and university education that have examined performance in subjects such as statistics or those of an analytical–methodological nature, either at a theoretical or empirical level. Examples of theoretical studies are those of Hunt and Tyrrell (2000) and Hodgson and Burke (2000). Hunt and Tyrrell (2000) highlight the significance of the introduction of new technologies,

in particular the Internet, in the teaching of statistics. On the other hand, Hodgson and Burke (2000) argue in favour of the introduction of simulations accompanied by a good introduction to the subject matter, as well as the monitoring and appraisal of the work undertaken by the students as essential elements in the best practice of the teaching of statistics and the evaluation of academic performance.

The studies that adopt an eminently practical approach are those that examine the importance of variables related to the role of motivation, personality and psychosocial factors (Castejón et al., 1996; Garrido and Rojo, 1996; Pérez-Sánchez and Castejón, 1996; Roces et al., 1997; García and Fumero, 1998) in the performance of students. Further studies identify a wide range of factors related to academic performance in the study of analytical subjects among university students, including previous academic record, in other words, the mark awarded in the University entrance examinations, performance in the pre-university course (*bachillerato* in our case) and the branch of studies selected during this pre-university course (Alvarado and García, 1999–2000 García et al., 2000), as well as attendance at and participation in the classroom (Alvarado and García, 1999–2000; García et al., 2000; Huberty, 2000). Finally, findings such as those made by Gal and Ginsburg (1994) and Garfield (1994) highlight the need to take into consideration students' attitudes towards and beliefs concerning statistics and Smith (1998), Boyle (1999) and Gardner and Hudson (1999) comment on the utility of students undertaking practical tasks in which they have to apply various statistical techniques while learning statistics. It is within this context that we should situate our traditional approach and this present study.

It was Barrios et al. (2000) who established the path taken by students in order to enter university (COU versus LOGSE), the branch of studies selected in the *bachillerato* (equivalent to the high school diploma, that is, option A/B – science or health sciences – versus option C/D – social sciences or humanities) and the mark awarded in the university entrance examinations (PAAU) as the predictive variables based on the fit of a stepwise optimal linear regression model. The results showed that each had a slightly significant effect in predicting academic performance, measured by the mark awarded in the final assessment of the subject.

In previous studies Guàrdia et al. (2002) and Peró et al. (2002), we proposed various modifications in the use of these variables, and extended some of the measures that we considered to be linked to performance in the subject of statistics. The main change was in the development of a Likert-style satisfaction scale (assessed on a scale from 0 to 7) concerning aspects related to the subject. This was based on the hypothesis that a student's satisfaction might be directly linked to his or her performance. This scale was generated *ad hoc* for each study, given the different teaching

programmes adopted in each academic year for the subject. In the first study (Guàrdia et al., 2002), the scale comprised 16 items, while in the second (Peró et al., 2002) 14 items were included, as the two items that referred to the teachers of the practical sessions were eliminated since in that academic year (2001–2002) the syllabus did not distinguish between the teachers of the practical sessions and the teachers of theory. The databases for both years were examined, among other analytical processes, using factorial analysis in order to study the underlying structure of both scales of satisfaction. In the data for the academic year 2000–2001 (Guàrdia et al., 2002), the 16 items were grouped in five sets of factors (satisfaction with the teachers, knowledge acquired, the teaching methods used in the subject, the teachers of the practical sessions and the teaching conditions) which accounted for 64.7% of the variability. For the data for the academic year 2001–2002, the factorial analysis included three factors (satisfaction with the teachers, importance attached to the subject and the organisation of the subject) which accounted for 55.15% of the overall variability.

The bivariable contrasts between academic performance and the factors obtained in the factorial analysis and other variables collected in the questionnaire were not statistically significant in the 2000–2001 study, while in the 2001–2002 study a statistically significant relation was only found with the branch of studies selected in the *bachillerato* (technical science and/or biology resulting in a better performance than humanities and/or social sciences). Furthermore, in both samples a study of the goodness of fit of a system of structural equations was undertaken, in order to determine which structure and factors influenced the academic performance of students enrolled in the subject of Data Analysis in Psychology. The overall results showed the effect on the two models of the following factors: First, the effects of the academic record prior to initiating university studies (the branch of studies selected in the *bachillerato*, the mark of the university entrance examinations, the fact of having studied statistics before or not, choosing of psychology as the first option when selecting which university degree to take and, finally, whether or not the student was repeating the subject); second, the estimated mark (the final mark that the student expects to obtain in the subject) and, finally, the factor of satisfaction expressed by the students (as regards the teachers, the information taught, the teaching methods used in the subject, the teachers of the practical sessions and the conditions of study for the academic year 2000–2001 and similarly for the academic year 2001–2002). In both cases the goodness of fit of the model was adequate. In addition, the three latent factors that were defined were statistically significant, although their relative weighting varied in the two studies. In the first (2000–2001), the latent variable "previous academic record" had greater importance, followed by the "estimate of the final mark" and finally the "degree of satisfaction", while

in the second (2001–2002), the "degree of satisfaction" obtained a higher importance, followed by "previous academic record" and finally the "estimate of the final mark".

The results of these studies show the well-known effect of dispersion that is typical in studies of academic performance. It is difficult to adopt a definitive position for a set of results since none is conclusive. However, the results for the group of students in the academic year 2001–2002 (Peró et al., 2002) provide a simpler factorial solution and, consequently, one that is more parsimonious in detecting factors that have an effect on academic performance in this subject. The structural models analysed form the two factorial solutions and, therefore, analysed in the two populations also show the dispersion discussed above (Guàrdia et al., 2002; Peró et al., 2002).

In this study we attempt to analyse the common information from the studies undertaken by Guàrdia et al. (2002) and Peró et al. (2002), which basically requires us to reconsider the factorial analysis undertaken in the first study (Guàrdia et al., 2002) and consequently the structural model. Once the structural model has been defined (identical in both years), we can then proceed to the study of its goodness of fit, as well as to a comparison of the indices of fit of the two academic years, in order to evaluate the stability of the proposed structure. The structural model that we propose studying for the two academic years is that analysed for the 2001–2002 data (Peró et al., 2002), and which is shown in Figure 1.

2. Method

2.1. SUBJECTS

We studied two samples of students enrolled in the subject Data Analysis in Psychology. The first sample comprised 211 students enrolled in the course in the academic year 2000–2001, while the second sample comprised 287 students enrolled on the course in the academic year 2001–2002. The choice of students that made up the two samples was determined entirely on the basis of those students that attended the class when the questionnaire was administered, and which in addition made the final examination (accidental sampling).

Of the students enrolled in 2000–2001, 18.7% were male and 81.3% female, with an average age of 19.7 years and a standard deviation of 3.5 years. Among the students enrolled in 2001–2002, 14% were male and 86% female, with an average age of 19.48 years and a typical deviation of 3.02 years. Given these data, we can conclude that the distribution of both variables was very similar in the two groups studied.

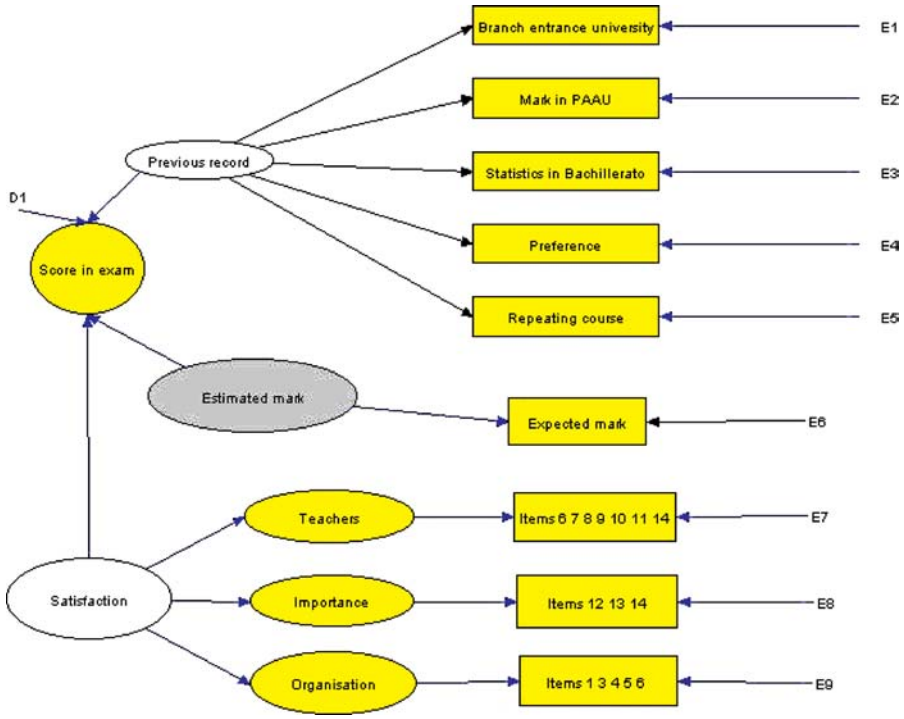

Figure 1. Diagram illustrating the proposed structural model.

2.2. MATERIAL

The material used comprised the subject examination and an *ad hoc* questionnaire based on an extension of that used by Barrios et al. (2000). The questionnaire aimed to gather information that might have an influence on the students' academic performance in the subject of statistics. The questionnaire contained the following information:

- Demographic variables: gender and age.
- Previous computer knowledge, how this had been acquired, if they have a computer at home and if they have an internet connection at home.
- Use of the electronic dossiers on the UB Web produced for the studying of the subject (syllabus, bibliography, statistical equation summary and solution of practical problems).
- Whether the student had taken previous courses in statistics, either the option offered as part of the studies in LOGSE or as a part of other courses.
- Whether the student had taken the subject of Basic Mathematics. A course designed to raise the level of those students encountering difficulties in analytical–methodological subjects in Psychology.

- Survey of satisfaction comprising 16 items on the questionnaire administered to students in the academic year 2000–2001 and by 14 items on that administered to students in the academic year 2001–2002. All the items were presented on a Likert-style scale where students responses range from *strongly disagree* (1) to *strongly agree* (7). The 14 items on the questionnaire administered in the academic year 2001–2002 can be grouped in the following four areas:
  - Aspects related to the subject, comprising the following three items:
    - the knowledge acquired is important for the rest of the degree (question 12)
    - the knowledge acquired is important for one's professional career (question 13)
    - overall, the subject deserves a favourable evaluation (question 14)
  - Aspects related to the teachers, comprising the following six items:
    - the teacher seems to master all aspects of the subject (question 6)
    - the teacher is able to motivate the class (question 7)
    - the teacher is able to awaken the interest of the students for the subject (question 8)
    - the teacher makes good use of the examples chosen (question 9)
    - the teacher has been willing at all times to deal with students' queries (question 10)
    - the teacher creates a friendly atmosphere which encourages participation (question 11)
  - Aspects related to the methodology adopted, comprising the following four items:
    - the time dedicated to each subject within the course is sufficient (question 2)
    - the system of evaluation used in the subject is understood and meets the requirements of the syllabus (question 3)
    - the dossier of practical problems is useful for the student (question 4)
    - the recommended reading list is useful for understanding the subject (question 5)
  - Aspects related to the conditions in the classroom, comprising one item, including the lighting, heating and ventilation of the classrooms are sufficient (question 1)

  The two items that were eliminated for the academic year 2001–2002 referred to the mastery of the subject demonstrated by the teacher of the practical sessions and to the degree of coordination between this teacher and the teacher of theory, because the course structure differed in the second year.

- The students previous academic record. Specifically, the mark awarded in the university entrance examination (PAAU) and the branch of studies selected during the pre-university courses (sciences or health sciences vs. social sciences or humanities).
- Data related to the subject studied. In other words, whether the student attended the class regularly, whether or not they were repeating the course, the mark they expected to obtain and whether the degree of psychology had been their first choice.

2.3. PROCEDURE

The questionnaire was administered to the students enrolled in the academic year 2000–2001 during the first fortnight of December 2000, while for the students enrolled in the academic year 2001–2002 it was administered between 17 and 21 December 2001. In both cases, the instructions given to the students emphasised the importance of answering the questionnaire sincerely given that its aim was to determine the factors influencing performance in the subject Data Analysis in Psychology and that it was very important to know the students' national identity number so that the results of the questionnaire could be compared with the final mark obtained in the subject. Students were reassured that the data gathered would be kept confidential and that the information would only be used for the purposes of the study.

The date of examination was on the 16 January 2001 in the case of the first sample and on 16 January 2002 in the case of the second. The score obtained in the examination, together with that awarded for the assignment undertaken as part of the course, gave the final mark for the subject out of 10, where 5 was considered the cut-off point between a pass and a fail.

The data analysis undertaken consisted of the fit of the structural model proposed in the introduction using the EQS program (version 5.1).

3. Results

As discussed above, we estimated the parameters and undertook a study of the goodness of fit of the structural model proposed in the introduction (Figure 1). In this figure, it can be seen that the mark obtained in this subject is determined by the student's previous academic record, the mark expected and their degree of satisfaction. The previous academic record factor is defined by the observable variables of the branch of studies taken by students in order to enter university, the mark obtained in the university entrance examination (PAAU), whether or not the student had studied statistics before, whether or not the student was repeating this subject of data analysis and whether or not psychology had been the student's first

Table I. Factor structure of the satisfaction scale based on the data obtained in the academic year 2001–2002.

Factor structure of the satisfaction scale established in Peró et al. (2002)	
Factors	Items
Teachers	– The teacher seems to master all aspects of the subject (6) – The teacher is able to motivate the class (7) – The teacher is able to awaken the interest of the students for the subject (8) – The teacher makes good use of the examples chosen (9) – The teacher has been willing at all times to deal with students' queries (10) – The teacher creates a friendly atmosphere which encourages participation (11) – Overall, the subject deserves a favourable evaluation (14)
Importance	– The knowledge acquired is important for the rest of the degree (12) – The knowledge acquired is important for one's professional career (13) – Overall, the subject deserves a favourable evaluation (14)
Organisation	– The lighting, heating and ventilation of the classrooms are sufficient (1) – The system of evaluation used in the subject is understood and meets the requirements of the syllabus (3) – The dossier of practical problems is useful for the student (4) – The recommended reading list is useful in furthering understanding of the subject (5) – The teacher seems to master all aspects of the subject (6)

choice of study at university. The factor of "mark expected" is defined by the observable variable mark expected in the subject (fail, pass, good, excellent and pass with distinction), while the factor of satisfaction is defined by three factors, namely, the teachers, the importance of the subject and the organisation of the subject, obtained by factor analysis based on the items on the satisfaction scale contained on the questionnaire administered in the academic year 2001–2002 (Peró et al., 2002). The resulting factor structure is shown in Table I.

The method of parameter estimation used in the two structural models studied was the elliptical robust least square method (ERLS) given the existence of categorical variables among the observable variables (Lee and Poon, 1994). Table II shows the indices of fit of the model analysed for the

Table II. Indices of fit for the model studied in the two academic years 2000–2001 and 2001–2002.

Indices of fit	Academic year 2000–2001	Academic year 2001–2002
BBNFI	0.801	0.978
BBNNFI	0.911	0.966
SRMR	0.002	0.008
$\chi^2 =$	35.392; df = 29; $p = 0.15875$	55.1278; df = 29; $p = 0.11$

Where BBNFI is the Bentler–Bonett normed fit index, BBNNFI is the Bentler–Bonett non-normed fit index, SRMR is the standardised root mean square residual and χ^2 is the chi-square index of fit.

student samples studied. In both cases, it should be noted that the fit of the model is good, with a goodness of fit of $\chi^2 = 35.39(p = 0.159)$ for the data corresponding to the academic year 2000–2001 and $\chi^2 = 55.128(p = 0.11)$ for the data corresponding to the academic year 2001–2002, and that the SRMR value (standardised root mean square residual) is 0.002 and 0.008, respectively, which indicates only a slight error and, consequently, a good data fit with the model in the two samples analysed.

Table III shows the standardised estimate of the parameters for the two groups under study. In the two analyses conducted, the parameters corresponding to the three factors that predict the mark obtained in the subject were statistically significant, with the exception of γ_{13} (satisfaction – examination score) for the data corresponding to the academic year 2000–2001. It should be noted that the relationship between these three latent variables and academic performance differs in the two analyses conducted. The first point to highlight is the fact that in the data corresponding to the academic year 2000–2001 the parameter estimate value is markedly lower than that obtained for the data corresponding to the academic year 2001–2002, the highest value in the estimate for the academic year 2000–2001 is 0.948 corresponding to the factor of previous academic record, while the parameter with the lowest value for the 2001–2002 data is 3.29 corresponding to the factor of expected mark in the subject. A second aspect to highlight is the fact that although the three factors have an influence on the final mark obtained by the students in the subject, their importance is not the same in the two groups analysed; thus for the data corresponding to the academic year 2000–2001 the factor with the greatest weight in the prediction of the mark is that of the previous academic record, followed by the mark expected in the subject and finally by the satisfaction with the various aspects related to the teaching of the subject. As for the results of the model for the data corresponding to the academic year 2001–2002, the factor that has the greatest weight in the prediction of the mark obtained by

Table III. Estimate of the model's standardised parameters based on the ERLS method for the data corresponding to the academic years 2000–2001 and 2001–2002.

Estimates	Academic year 2000–2001	Academic year 2001–2002
γ_{11}	0.948 *	4.07 *
γ_{12}	0.313 *	3.29 *
γ_{13}	0.053 **	5.12 *
λ_{43}	0.421 *	0.842 *
λ_{53}	0.759 *	0.718 *
λ_{63}	0.377 *	0.601 *

* $p < 0.05$; ** Non-significant.
γ_{11}: previous record – score in exam; γ_{12}: estimate mark – score in exam; γ_{13}: satisfaction – score in exam, λ_{43}: satisfaction with teachers – satisfaction; λ_{53}: importance attached to the subject – satisfaction; and λ_{63}: organisation of the subject – satisfaction.

the students is satisfaction with the various aspects related with the teaching of the subject, followed by the previous academic record and finally the mark expected in the subject.

Finally, Table III also shows the standardised estimate of the parameters corresponding to the latent factors that account for the factor of satisfaction, that is, in relation to the teachers, the importance attached to the subject and the organisation of the subject. Here once again there was a repetition of the phenomenon described earlier, the estimated value of the parameters is notably lower in the case of the data corresponding to the academic year 2000–2001 than for the data corresponding to the academic year 2001–2002.

4. Discussion

The analysis of the proposed structural model shows satisfactory indices of fit for the two data bases studied ($\chi^2 = 35.392$; $p = 0.159$ for the data corresponding to the academic year 2000–2001 and $\chi^2 = 55.128$; $p = 0.11$ for the data corresponding to the academic year 2001–2002). In fact, the values of these indices are very similar, with the Bentler-Bonett normed fit index showing the greatest discrepancy between the two analyses (0.801 for the academic year 2000–2001 as opposed to 0.978 for the academic year 2001–2002).

The three factors (previous academic record, estimate of the mark and satisfaction) proposed here as predicting the final mark obtained in the subject do have such an influence, as has already been demonstrated, albeit

only in part, in earlier studies (Alvarado and García, 1999–2000; Alvarado et al., 2000; Barrios et al., 2000; Guàrdia et al., 2002; Peró et al., 2001). However, the importance of these three factors in predicting the mark is not the same in the two databases. For the data corresponding to the academic year 2000-01, the most important factor is that of the previous academic record, followed by the mark expected in the subject and finally by the satisfaction, which, moreover, is not statistically significant; indeed, this is the same pattern as that found in the structural model analysed by Guàrdia et al. (2002); by contrast, in the case of the data for the academic year 2001–2002, the factor with the greatest weight in the prediction of the mark obtained by the students is satisfaction, followed by the previous academic record and finally the mark expected. This result suggest that there is no stability in the proposed structure. A further argument against the stability of the structure is the marked difference in the estimate of the standardised parameters for the two data bases studied, with the estimated values for the data corresponding to the academic year 2001–2002 being much higher than those estimated for the academic year 2000–2001.

The results obtained show the well known dispersion effect in the study of academic performance. Despite the good fit of the data with the model for the two samples studied here, we have to conclude that there is no stability in the proposed structure, and that possibly the factors that influence the students' academic performance in the subject of Data Analysis in Psychology should be sought adopting a different approach.

Here again the difficulty in predicting a person's academic performance accurately is patent. It might be the case that there exists a very large group of factors that are not readily operationalised, but which influence the outcome. Furthermore, the difficulties faced in the statistical modelling of a phenomenon such as academic performance should be considered, particularly where individual differences and those that are generated between the times of measurement have a marked influence on the process. Prior information will not always be a good predictor of the subsequent performance of all people, and this can be attributed to varying degrees of motivation in a person′s academic studies. Students at university are assumed to be studying a subject that they have chosen and it is to be hoped that their motivation and interest for this subject will be greater than that shown during primary and secondary education, which would uphold a more dynamic conception of the educational process.

To conclude, taking into consideration the three latent factors that we studied in the structural model what seems to be needed are procedures of direct intervention. Indeed, as regards the factor of previous academic record, we believe that it is vital to strengthen subjects that might raise the level of the students who have little training in maths, such as Basic Mathematics discussed in the introduction, in order to homogenise the prior

mathematical knowledge needed to perform successfully in the subject of the Data Analysis in Psychology. If this occurs, it seems logical to think that the second factor, students' expectations, will be influenced by the degree of prior preparation. Thus the students, in line with their level of knowledge at the outset will express greater expectations concerning their own future performance in the subject.

It would be interesting to examine in more detail the effect on the degree of satisfaction expressed of recent developments in the quality of teaching, including:

- The use of new technologies of information and communication:
  - computer presentation of subject matter
  - use of computer-based statistics programs
  - e-mail correspondence with the tutor
  - virtual presentation of exercises by the students
- evaluation system based on continuous tests.

Clearly these changes in the delivery of the subject will need to be analysed and studied, in the near future, in order to obtain sufficient evidence so that they might be adopted in the actual teaching setting.

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