STATISTICS EDUCATION APPLIED TO AGROFORESTRY AREA (2005)

Esperanza Ayuga Téllez, Concepción González García and José M. Moral Medina
Universidad Politécnica de Madrid, Spain
esperanza.ayuga@upm.es

Applied Statistics may be regarded as a basic as well as technical subject in engineering, and therefore play a central role in the agro-forestry engineer professional curriculum. With the purpose of implementing a new learning method for statistics, within the framework of European Higher Education, an experimental evaluation was organised along a quarter in the academic year 2004/05 for students following the third grade at the Faculty of Forestry Engineering in the Madrid Polytechnic University. The teaching methodology goal was to improve students' oral information searching, use of technologies and analysis and synthesis capacities, while, at the same time providing them with a basic knowledge about the subject.

GLOBAL EDUCATION OF ENGINEERS

The technological evolution and the possibility of working in very distant locations support the idea of linking the practical training necessary to the work of engineers with a basic education which is wide enough to allow a long-range vision of professional activity. In this way, engineers will be able to adapt to new methods and techniques as well as to new work organisation.

What really matters in higher education is not the contents the students learn during the training period, but their acquisition of capacities and their development of social abilities needed in their future professional work. This is the reason why basic subjects play such an important role in engineering education. Applied Statistics is, at the same time a basic and a technical subject, and therefore plays a central role in the professional curriculum for agroforestry engineers.

The teaching in an engineering school should be pragmatic, while carried out on a scientific basis to avoid that the excess of pragmatism might turn education almost useless a few years after graduation. According to Casas (2003): "*The key achievement for our professionals' success is they can think and communicate. This goal will be reached by keeping a pure science based core. We should not forget the indispensable when thinking in the important …, because, our final work is giving responses.*" Knowledge of basic subjects such as mathematics, mechanics, thermodynamics, hidraulics, soil science, meteorology, chemistry, biology, drawing, construction, etc. is therefore indispensable and should have an important weight in the whole education of all agroforestry engineers.

In several recent meetings of engineering professionals (Ayuga, 2003; Ayuga, González and Martínez 2003; Carazo, 2003) we have emphasized the relevance of an appropriate positioning when facing others in both professional work and access to new employment. A relevant issue in professional capacitation is human education in the sense of acquiring capacity for team work, appropriate results and attractive presentation of results, and convincing others of correct and necessary conclusions. These important aspects of professional work are frequently neglected in the traditional university education.

IMPORTANCE OF STATISTICS EDUCATION IN AGRO-FORESTRY ENGINEERING

Statistics is present in our whole life. It is related to decision-making in a variety of situations like bringing an umbrella when leaving home, predicting the Parliament composition before the scrutiny of votes in the elections day or calculating the consumption price index. In all these situations Statistics is used as a fundamental tool, but also in many other topics. Some curious examples are text author identification (Mosteler and Wallace, 1989), searching different meanings for similar words (Rosenberg *et al*. 1968), jury selection (Press, 1989), determining paranormal phenomenon (Paulos, 1990), evolution of endangered populations (Petersson, 1998), determining growth patterns in trees (Legaré *et al*. 2005), locating oilfields (Whitney, 1989), assigning fossil wreckage to an species (Howells, 1992), etc.

Statistics is an inductive science which intends to adopt optimum decisions based on experience. Therefore future engineers will need along their education and posterior professional work statistical tools to analyse real situations and systems.

The fundamental objective for a researcher analyst is to faithfully reproduce the behaviour of the real phenomenon through a process composed of data collection, data process, interpretation of results and identification of main characteristics and relationships. The whole process will be a very important resource for engineers and therefore, statistics knowledge is so important for future professionals as managing vegetal production or evaluating environmental issues impact.

Agro-forestry engineering work extends over large areas and time periods, and therefore it is essential to summarise large amounts of data such as trees age, wood volume and growing in a few characteristic values. It is also important to find possible relationships between variables and producing forecasting models. It is not usually possible to use all the data of all individuals, so that representative samples should be selected to produce inferences. Methods such as statistical quality control, market research, experimental design, materials acceptation plans, optimisation methods and decision-making are used in both private and industrial engineering work.

AN EXPERIENCE IN THE ACADEMIC YEAR 2004/2005

We adopted the SYLLABUS experience (Jolliffe, 2002) as a reference with the purpose of implementing a new learning method for Statistics within the framework of European Higher Education. An experimental evaluation was organised along a quarter in the academic year 2004/05 for students following the third year of studies at the Faculty of Forestry Engineering in the Madrid Polytechnic University. Only 55.4% (72 students) volunteered to collaborate and took part in the experiment. The remaining students followed a conventional course. About half of the students in the experimental group (30 students) took a written exam at the end of the quarter.

Participants in the experimental groups were distributed into 18 groups each of them ranging between 2 to 6 members. Each group was to find information on the themes under study and present their conclusions in a written report and orally. Furthermore, they worked under supervision with a statistical computer package with a data set elected by themselves. The following statistical themes were covered is the course:

- Point and interval estimation.
- Parametric and non parametric hypothesis tests.
- Linear regression and experimental design.

The total teaching time was 34 hours, ten of them devoted to computer practices using *STATGRAPHICS* Plus 5.1; nine hours were devoted to theoretical lessons, eight to problem solving and six hours to students presentation of their work. All the groups had to participate in every presentation of their classmates by asking questions to their colleagues when presenting their work. The group presenting its work each day was selected at random with replacement so that the same group might be selected to present more than a day. A partial scoring for each part of the assignment followed the scheme in Table 1.

Table 1: Scheme for scoring the students work

	Theme 1	Theme 2	Theme 3	Total
Work	0 - 1,5	0 - 1,5	0 - 1,5	0 - 4,5
Presentation and questions	0 - 1,5	0 - 1,5	0 - 1,5	0 - 4,5
Total	0 - 3	0 - 3	0 - 3	0 - 9

Practical work with computer included five 2-hour long practices in different days. Participation and presentation of conclusions were evaluated each of these days and a maximum of 1 point was scored. It was possible to get the maximum scoring with work presentation, associated questions and practical computer work without need to carry our the final exam.

RESULTS

Practices combined three different exercises oriented to students getting some abilities necessary for professional engineers as follows:

- Oral presentation, this practise serves to improve oral expression.
- Computer use to solve problems with real data, which introduce students to tools which are frequently used in professional job.
- Searching and summarising information about a particular theme, which requires analysis and synthesis capacities and use of TIC's (Technologies of Information and Communication).

The methodology in the academic year 2003/04 consisted in lectures, problem solving and practices with statistical software. The evaluation of results consisted in a single examination with a theoretical part of short questions and a problem solving part.

In Table 2 we summarise the results of students who passed the test in the two years.

Table 2: Comparison between academic years

	Number of students who:			%
Year	Registered in the course	Took the exam	Passed	(from all who took the exam)
2003/04	190	160	74	46.2
2004/05	133	100	82	82.0

Most of students who did not participate in the experience had been inscribed in 2003/2004 class and followed the traditional learning methodology explained above. Therefore, the results in this group were similar to those in course 2003/04 (see Table 2).

To complete the comparison of global results a test of the knowledge acquired was proposed to the students at the end of the experience (2004/05). The test contents were equivalent to the theoretical part of 2003/04 examination.

One hundred sixty students took the exam in academic year 2003/04. The distribution of marks in this group was acceptably Normal (the Pearson χ^2 test yields a p-value equal to 0.24029) with a mean of 4.19 and a standard deviation of 1.56 in a range from 0 to 10.

Fifty six students from the experimental group fulfilled the test in the academic year 2004/05. The distribution of scoring in this group was also acceptably Normal (p-value = 0.44092) with a mean score of 6.17 and standard deviation 1.75.

After testing the hypothesis of equality of standard deviations and means between both groups the equality of variances was accepted at the 5% level and the equality of means was rejected (p-value = $6.47.10^{-7}$). Therefore it was assumed that in the academic year 2004/05 the average mark was higher. The estimated average difference as 1.25 points on a scale from 0 to 10. The 95% confidence interval for the difference between the means assuming equal variances: 1.24951 ± 0.49434 is [0.755169, 1.74385].

These results may have been influenced by differences in initial background and motivation between the group of students who volunteered for the experience and the remaining students. However, we have to point the following qualitative aspects:

- The global satisfaction with the experience was evident.
- The level of attendance to lectures was higher than with the old methodology and is more stable until the end of year.
- There is higher interest and involvement with Statistics since the class work affects directly to marks.
- The students become more aware of the usefulness of Statistics in professional activity.

CONCLUSIONS

The learning methodology in our study was oriented to enhance students capacities for oral expression, information search, use of technologies, analysis and synthesis, together with acquisition of a basic statistical knowledge. The observation confirms that these capacities have been improved although we have not quantitative measures. Up to the moment we have only assessed results related to knowledge because they are the only we could compare with the students in the previous year. The experience showed a significant improvement in these aspects when compared to those from students not included in the experiment.

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