

Agroforestry: Participative Education in Statistics

E. Ayuga Téllez ^{*,1}, C. González García ¹, J. Moral Medina ¹ and A. Martín Fernández ¹

¹ Grupo de Innovación Educativa en Técnicas Cuantitativas para la Ingeniería Medioambiental. Universidad Politécnica de Madrid. Ciudad Universitaria s/n. 28040. Madrid. Spain.

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. The strongest point by the students were able to apply the conceptual statistical analysis techniques they learned in the classroom to a real world data with the aid of Excel and STSTGRAPHICS.

Keywords Statistics education, agroforestry.

1. 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.

The contents the students learn during the training period is not what really matters in higher education, 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 place in the professional curriculum for agroforestry engineers.

Teaching in an engineering school should be pragmatical while carried out on a scientific basis to avoid that the excess of pragmatism, which might turn education almost useless a few years after graduation. According to Casas [1]: "The key 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', hydraulics, 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.

Several recent meetings of engineering professionals have emphasized the relevance of and appropriate positioning facing others to 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 traditional university education [2].

2. 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

* Corresponding author: e-mail: esperanza.ayuga@upm.es, Phone: +34 913366401

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 [3], searching different meanings for similar words [4], jury selection [5], determining paranormal phenomenon [6], evolution of endangered populations [7], determining growth patterns in trees [8], locating oilfields [9], assigning fossil wreckage to an species [10], 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 fininf these 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 acceptance plans, optimisation methods and decision-making are used in both private and industrial engineering work.

3. Method.

The number of students registered in this subject for the academic year 2004/2005 was 130. After giving them some information about the teaching methodology and the norms of assessment for the two parts the quatrimester is divided into, i.e., a third partial term including statistics inference topics, regression models and variance analysis models, design of experiments, and a fourth partial term including sampling techniques specifically applied to the forest sector, the number of students who decided to collaborate in the experience were demanded to answer, in a reliable way, the questionnaires and surveys presented and to try to time their work on the subject.

The group of students who preferred to follow the traditional method (attendance to classes and final exam) was the witness group to compare results. The results of the experiment hardly affected the final mark of the student [11].

The in-school period was from 1st of February to 19th of May of 2005.

The period corresponding to the third partial exam was from 1st of February to 17th of March and the following three thematic units were explained: 1. Point and Interval estimate, error estimate and sampling coverage; 2. Estimate and testing of parametric, non-parametric, and hypotheses; 3. Variance analysis, lineal and advance regression. Design of experiments.

At the end of each unit the students were delivered, with no former notice, a test-type questionnaire that was corrected in class (self-evaluation) and subsequently given back to the teacher. In order to complete the final mark for the unit the student had to present and expose a work of his, and so the evaluation was followed in Table 1.:

Table 1 Final marks per concept, third partial period.

CONCEPT	Every unit	TOTAL
Work	0 – 1.5	0 – 4.5
Dissertation/Discussion	0 – 1.5	0 – 4.5
TOTAL	0 - 3	0 - 9

The period corresponding the fourth partial exam was from 29th of March to 19th of May and the units exposed: 1. Basics on survey sampling; 2. Traditional sampling models; 3. Other types of sampling.

The methodology followed was the same one used in the previous partial term but, due to the fact that the units were more practical and that the theoretical concepts were the ones studied throughout the whole course, the students were demanded a unique work in which the three thematic contents were applied to a real situation with real population and limited size. The assessment model was as follows in Table 2.

Table 2 Final marks per concept, fourth partial period.

CONCEPT	TOTAL
Work	0 – 4
Dissertation/Discussion	0 – 2
Optional Section	0 - 2
TOTAL	0 - 8

Seven practices were carried out by using the computer; the outlines of the practices included the solving of problems related to the units explained in the quadrimester (the practices with computer of the first partial term would be useful to accomplish the sampling work). The attendance and realization of the practices in each partial term were marked from 0 to 10. The attendance to the class in the fourth partial term was also evaluated from 0 to 10.

In the practice work students were able to apply the conceptual statistical analysis techniques they learned in the classroom to a real world data set. Students had a participative attitude applying with the aid of statistical software (Excel and Statgraphics) [12] estimation, sampling [13] and regression techniques. Excel and Statgraphics statistical software are the standard for classroom teaching because they enable students to hone their statistical analysis and develop practical problem-solving abilities that apply in the real world.

4. Results.

This work presents the results and conclusions achieved after having applied the teaching and assessing methodology accomplished on the first-year subject Technical Drawing and the third-year subject Applied Statistics [14, 15] both belonging to Forestry Engineering Studies, throughout the academic year 2004/2005 [16, 17]. The aim of this methodology is the improvement of the learning strategies for both subjects, the acquisition of a series of skills and more accuracy in the real time required for students to carry out their work out of the classroom. In this way, we will better know the teaching aspects to be improved, modified or eliminated in the next years and so a better estimate of the number of European credits(ECTS) [18] required for these subjects once the new curricula are prepared.

Table 3 shows the summary of marks in the third partial exam (2004 – 2005)

Table 3 Summary of marks in the third partial exam 2004/05.

Tipo	n	\bar{X}	Me	s_{n-1}	e	CV
ECTS	72	8.1	8.1	0.648	0.076	8.1
Group reference	30	4.4	4.3	1.928	0.352	43.5
absent	28					

Percentage of passes: ECTS Group 100%Reference Group 33.3%

Average time necessary to finish the works . 76 hours (CV 40%)

Table 4 shows the summary of marks in the fourth partial exam (2004 – 2005)

Table 4 Summary of marks in the fourth partial exam 2004/05.

Tipo	n	\bar{x}	Me	s_{n-1}	e	CV
ECTS	96	6.2	6.3	0.801	0.082	12.9
Group reference	8	5.9	5.5	1.280	0.452	21.7
absent	26					

Percentage of passes: ECTS group 100% Reference group 87.5

Average time necessary to finish the works . 23 hours (CV 40%)

Total hours for the fourth quatrimester (that is, both third and fourth partial exams): 75 class hours

- 14 hours for practice tasks using computer tools
- 18 hours for the solving of problems
- 21 hours for oral presentations of the works
- 22 theoretical hours

4. Conclusion.

The number of failures decreases enormously, above all if we only consider the in-school period and both partial examinations. In other words, most of the students do not have to make an overeffort since there is no need to take a final exam.

There is a slight increase in the average mark of the students who passed per academic year (16% in Technical Drawing and 20% in Applied Statistics). However, that difference is not significant if compared with the marks obtained in the final exams.

The students valued the method highly. They felt more motivated and their implication in the subject was also higher. Nevertheless, they considered that the method was more time-demanding.

The teacher achieves a deeper knowledge of the learning level acquired, both quantitatively and qualitatively, and the attention devoted to the students is more specific. Moreover, the learning skills increase considerably.

The estimate realized was based on the information the students provided about the number of hours required for each subject out of the classroom.. If we consider this data as a whole along with the number of in-class hours, the traditional system of credits can be transformed into the new system of European credits, taking into account that 1 Ects credit corresponds to 25 – 30 working hours per student.

Applied Statistics (2nd Semester): 7.5 traditional credits become 4 European credits.

Overall, the experience was so positive that, for its revision and improvement we have applied it again in the current academic year.

References

- [1] J. Casas Grande, Los Ingenieros de Montes y su identidad profesional. I Congreso Profesional de Ingenieros de Montes. Sesión 1. Madrid, Spain (2003)
- [2] E. Ayuga, C. González and J. Moral,. Statistics Education Applied to Agroforestry Area (2005). 7th International Conference on Teaching Statistics: "Working Cooperatively in Statistics Education". Salvador, Brasil (2006)
- [3] F. Mosteler, and D.L. Wallace, (1989) Deciding Authorship in Tanur et al (eds) Statistics: A Guide to the Unknown. (Wadsworth & Brooks, California, 1989). pp 115-131.
- [4] S. Rosenberg, C. Nelson and P.S. Vivekananthan, A Multidimensional Approach to the Structure of Personality Impressions. Journal of Personality and Social Psychology, **9**, (1968) pp 283-294.
- [5] S. J. Press, Statistics in Jury Selection: How to Avoid Unfavorable Jurors en Tanur et al (eds) Statistics: A Guide to the Unknown. (Wadsworth & Brooks, California, 1989). pp 87-92
- [6] J. M. Paulos, El hombre anumérico. (Tusquets Editores, Barcelona, 1990).