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TEACHING STATISTICS TO PRODUCTION PERSONNEL

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1. Introduction

The highly competitive situation existing for many products and in many markets, together with customers' increasing demands (quality, reliability, safety, etc.), has moved companies to improve, among other aspects, their production quality.

In the world of industrial quality, statistics plays an essential role. As Deming (1982) says, no other resource is in such short supply in companies as statistical knowledge, and no other can help so much to increase quality and productivity. Guided by this principle many enterprises, following the big international car manufacturing companies have launched training programs for their employees in which, and under different names (Statistical Process Control, Statistical Methods, Statistics for Non-production Departments, ...) statistics-related knowledge is taught. The courses offered vary as widely as the needs that may appear in the industrial environment, from basic statistical knowledge to design of experiments and other advanced techniques. It is also true that, sometimes, methods which are not strictly statistical are included together with statistics, as happens with some of the seven Japanese tools.

2. Contents of the training programs

As suggested before, a wide variety of subjects is included in the different courses. Usually these subjects are grouped under the following headings:

Descriptive methods. Different kinds of tables and graphics are presented, and their adequacy for each situation, construction and interpretation are discussed.

Probability. It is, perhaps, the subject least studied in these courses, except in the advanced ones, where the definition of probability and its basic properties and theorems are discussed. At the other levels, only an intuitive approach is usually presented.

Probability distributions. Among the discrete distributions, special emphasis is given to the Binomial and Poisson because of their application to quality control where variables are classified by discrete attributes. The Normal distribution (very important for quality control of continuous variables) is also studied and, depending on the level of the course, t, F and chi-square distibutions are presented. One other distibution used, but not theoretically analyzed, is the Pareto distribution, which occurs in one of the Seven Tools (the "Pareto Analysis").

Regression and correlation. The concepts of correlation coefficient and simple regression are explained, as well as the idea of the least squares method. Computation of the model parameters and a graphical non parametric method are also touched on.

Comparative studies. Usually centered on the paired test for means and variances (t and F tests). In advanced courses ANOVA techniques are also included.

Design of experiments (DOE) and Taguchi techniques. Starting from the basic concept of the need for initial experimental design as exposed in basic courses, at advanced levels there are monographic courses devoted to DOE, from both classic and Taguchi approaches.

Statistical Process Control (SPC). SPC techniques are a set of estimation and hypothesis-testing methods, combined with a graphical analysis method. The different kinds of control charts, adapted to different process needs, make use of the Binomial, Poisson and Normal distributions. In addition to the standard Shewhart method, and depending on the type of industry, CUSUM and EWMA charts are also explained.

Acceptance control. This course includes techniques for acceptance sampling of the finished product. Usually it is oriented towards the use of standards like MIL-STD 105D or MIL-STD 414 (or their equivalents in Spanish UNE standard) and the Dodge-Romig Tables.

Sampling. Concepts like randomness and representativity of the sample are defined and commented on. Computation of sample size for various circumstances is also studied.

3. Conditioning factors in the students

The main conditioning factor in the persons attending these training programs is their heterogeneity. In concrete terms:

- In the same kind of course, and frequently in the same group, the levels of the students are very different, not only in their mathematical and statistical backgrounds, but also in other general aspects.
- Secondly, and also very often, interest in the subject of the course varies from those who are enthusiasts for a technique they consider as very useful for their job, to those who are forced to attend the course by the management and/or don't find the subject of the course applicable to their present job, and show a lack of interest in or even reject the material.
- Thirdly, there are students who come from different departments of the company, having different approaches and points of view, thereby making it difficult to find examples of general interest.

Another characteristic of the students is what we can call a "strong wish for early application" of the knowledge they receive in the courses. This defines three groups of persons:

- those who find the tools presented in the course of immediate utility and are highly motivated by this usefulness;
- those who find the tools of low applicability to their job and who show lack of interest in and perhaps reject the course;
- and finally, those who, perhaps without seeing any immediate application of the technique to their job, are interested in knowledge and tools that they consider useful.

The attitudes derived from these three groups seriously affect the development of the courses.

Together with these attitudes of the students, and probably a partial cause of some of them, is the attitude of the management, who frequently demand immediately applicable results from the courses, by means of suggestions, improvements, studies, etc., sometimes confusing training with consulting.

4. Methodological outlines

The characteristics of the students and of the matter to be taught, plus the fact that this is non-academic teaching, have determined a certain approach and teacher attitudes adapted to such factors. The main characteristics are:

- Reinforcement of the intuitive approach rather than the rigorous mathematical approach, both in the definition of concepts and in the presentation of techniques and analysis of results.
- Frequent use of examples taken from the immediate environment of the students (to increase the interest in and motivation by the course).
- Importance of individual and team work of students using real data obtained by themselves.
- Use, limited by the heterogeneity of students, of different computation devices (pocket calculator, computer) to relieve students of tedious repetitive calculations and make the use of more advanced, and complex techniques possible. Related with this point, it is interesting to mention the difficulties we find in using informatics, due to the fact that, especially in some levels, students have very little experience in this field, requiring prior introduction sessions. Only high level courses are free of this problem.
- The need to have clear and specially adapted material, for both examples and the content of the course.
- Use of simple language, avoiding technical terms and complicated constructions.
- When mathematical expressions are used, placing more emphasis on the sense than on the expression itself: explaining the formula.

5. Positive and negative aspects of the training programs for production personnel

We will speak briefly about advantages and disadvantages that training activities like these have for companies, the personnel receiving the courses and the university professors involved in them.

For the companies, collaboration with universities facilitates access to specialists in areas usually not found in the industry. In the area of statistics this is especially true (remember the sentence by Deming quoted before). Sometimes it can be difficult to gain acceptance of the contents and approach to the courses from university professors, who have the habit of making wide use of a mathematical approach to statistics.

Personnel attending the courses have a very good opportunity of receiving complementary training, which is sometimes very limited, in areas of interest to their job. They receive information on new methods and revise their way of working, adapting it to technical developments and to company policies. Inconveniences may result from poor selection of the persons attending each course, causing difficulties to the whole group.

For the university professors involved, these training programs are good opportunity to demonstrate the practical uses of their knowledge, to apply this knowledge themselves and to adapt their interests (related to teaching and research) to society's demands. Our university produces mainly engineers in different branches, and thus it is very important to keep teaching in contact with reality. There is a real danger of using a level (mathematical, technical, ...) of the industry training programs in the university courses, that could cause, from our point of view, a loss of quality in academic teaching. In any case, the advantages are greater than the disadvantages. University teaching is improved by different factors: firstly, the need for conceptualizing, frequent in industry training, can be, to some extent, used in some academic courses. Secondly, the contents of university courses change to fit industry needs, improving the future engineers' background. Thirdly, there will be many real examples of the use of statistical methods, increasing the motivational level of students (Barnett, 1983). And fourthly, real experience in industry causes the appearance of new research fields that can lead to new developments, as has happened frequently in the history of statistics and operations research.

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