Real Data and Statistics in the Mathematics Education. What is coming out of a Research on Teaching Strategies for the Learning of Statistics

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1. Introduction

In a school environment still reluctant to recognise the specific and autonomous role of statistics for the education of every youngster, we proposed and realised a research, recognised as one of the more significant teaching experiment and surely the more relevant for the teaching of statistics in our country. From May 1999 to June 2000, in four regions of Italy, at the three different levels of schools (primary, secondary and superior) every step was accomplished: schools and teachers recruiting, teachers training, classroom experimentation of a basic statistic course with different teaching approaches. About 3000 students and 2000 teachers in elementary schools, 2300 students and 110 teachers in secondary schools and 2500 students and 113 teachers in superior schools completed every step of the experimentation. . In this paper we will talk about the superior schools and we will present the first evaluation of the experiment.

2. Content and Pedagogy for an Introductory Course of Statistics

For sometime, rich and interesting debate concerning the problems of statistic teaching has taken place on the international scene. Based on the recent contribution of D.S. More, (1997) entitled *New Pedagogy and New Content: The Case of Statistics*, and also taking account of the situation of the teaching of statistics in Italian schools, we proposed a research plan that had as principal aim the experimentation of teaching strategies for the learning of statistics in superior schools. Actually, a basic statistics course was designed, three different teaching strategies were chosen and teaching material was prepared. The mathematics teachers coming mostly from Scientific High Schools and Technical Institutes were divided in three groups according to the teaching approach they would experience in their classroom and they followed a specific training with the material prepared for the experimental course. The attribution of the teaching approaches was not random but followed as much as possible the choices expressed by the teachers themselves. Finally, in the springtime, the classroom experiment was actualised.

The basic course

In our school, a basic statistic training with a particular concern for the use of real data and official statistics is strongly suggested: have the students acquire the ability to read a data table is certainly an essential objective because this competency will always be more and more necessary for the citizen of a society increasingly overwhelmed with information (which is also quantitative). Also in creating the basic course for the classroom experiment, consideration was given to the collection of data, to their organisation in table and graphic format, to their synthesis using central and dispersion measures, and their comparison with similar situation in various context; all this was prepared for about 15 to 20 hours of lessons.
The teaching material consisted of:
A rather detailed guide for the teachers that included the following content units:
  1. Statistical information
  2. Statistical survey
  3. A questionnaire for the collection of data

4. The collection of data
5. Frequency distributions
6. Lecture and interpretation of tables
7. Graphic representations
8. Central measures
9. Variability measures
10. Students working sheets for each content unit
11. Students tests sheets for each content unit

The teaching strategies

Three teaching strategies were chosen but they all had basically in common a "data oriented" approach that had the students proceed through every step of a statistical survey, from the planning of the survey to the processing of the collected data. The three teaching modalities were:

1) traditional teaching with frontal lessons based on a Data Oriented Approach (DOA);
2) traditional teaching with frontal lessons based on DOA with laboratories activities (using computers) (DOA+ LAB);
3) "Cooperative learning" approach based on DOA with laboratories activities (using computers) (DOA+ LAB+CL);

For each of these teaching modalities, there was a specific guidebook but the contents were the same and also the activities for the collection and processing of the data. The theme chosen for the organisation of the questionnaire and the collection of data was: *Aspects of everyday life (family, transportation, eating habits)*. This theme, even if not very original for the students, had the big advantage of allowing the utilisation of official statistics (tables from a "Multifocus enquiry" produced by ISTAT) thus permitting the comparison of data collected and observed by the students in their own context with the national and regional data.

Monitoring of the experimentation

To maintain a "certain" control on the experimentation in classrooms we asked the teachers to complete a journal where they would note down what was going on while the experiment was underway. For each lesson, they also had to provide an autoevaluation judgement and register the students' reactions.

To assess what the students learned, three different tests were prepared. The first one, to establish their initial ability to read data, the second was passed at mid-experimentation when the graphic representation unit was completed and the third and last one at the end of all the experimentation. The teachers were interviewed at the beginning of the training course to record their motivations and expectancies concerning their participation to the research program and to analyse their attitudes towards statistics. At the end of the experimentation, they were asked to express an analytical judgement on the whole experimentation.

3. Problems

A first relevant problem was encountered during the teachers training. Even if it had been clearly indicated since the beginning and in a very insisting manner, teachers were still expecting a course in a "classic" format where a greater importance would have been given to more advanced statistical contents, in particular on statistical inference. We had to fight a certain sufficiency felt towards "The Statistics of data". Step by step, while the training course was going on, the teachers consciousness of the importance of an initial approach based on the organisation of a statistical survey and the analysis of real data produced by the students themselves or taken from official references increased

but we had to wait until the last moment of the training course to have a full and unconditional adhesion. After having experimented in class the teaching units, following step by step the guide that was provided for them, there was maturation and a complete recognition of the importance of the suggested trail. Very few dropped out and for reasons such as health problems or external constraints that did not allow them to pursue the experimentation in the lap of time expected.

A second problem pointed out by almost every teacher was the need for a text that the students could use to study. However, the preparation of the "guidebook" for the teacher necessitated an important investment of time and energy and there was no time left to prepare theoretical text for the students. We counted on the "working sheets" provided with the teacher's guide and on the teacher ability to use the references provided with the guide. However, this demand will be fulfilled soon because we will offer a complete text for those who will want to continue to use the experimental material.

An another noticeable problem: the teachers that volunteered for the experimentation had the same instruments, material and teaching approaches but they worked with classroom of different age groups and curricula. The course was prepared for 16 to 17 years old students (or we could say for the second or third year of the superior schools), but because of the way statistics is planned in the school curriculum, we had to work with teachers of the 3rd and 4th year of superior schools. It was noted that in certain schools even if they had not done any statistics before, the proposed activities were judged too "easy" relatively to the work asked in other disciplines and respectively to the students' capacities. The results of the tests will permit us to evaluate better these observations.

4. Feedback from students and teachers

Some preliminary conclusions can be drawn from the comments expressed by the teachers at the last meeting at the end of the experimentation or in the written reports they sent us and also from a first lecture (even if incomplete) of their journals.

Their comments were rich and precise: the teachers were fully satisfied. They recognise the competency and professionalism of the experts (statisticians, pedagogues and psychologists) during the training courses and the quality of the teaching material prepared. They fully collaborated and followed all directives and conditions imposed by the experimentation plan. Recurrently these mathematics teachers with little background in statistics expressed the fact that they succeeded to "catch" the spirit of the discipline and to give the proper importance to the teaching approach based on the analysis of real data. The comment of one of the teacher represents well the opinion expressed by many teachers that participated to the experimentation:

> *This teaching approach is a winner, the use of real data, the ones collected in class by the student and also the ones taken from the official tables of ISTAT that you gave us was very advantageous because examining them, it has been possible to extract numerous information necessary to understand the observed phenomena. In my past experience, I used only anonymous tables taken form textbooks, usually not very significant because they gave little attention to the data themselves; they were used only to do computations useless to understand the entire statistical strategy.*

Up to now, the superior school teachers were more interested in the disciplinary contents and the respect of the schedules determined by the curriculum than by the psychopedagogical aspects that could facilitate the learning of the students. Developing a cooperative learning experience, establishing relations with their students from a "constructivist" point of view, using technology to attain their objective in a sensible and efficient way has given the experimentation a "novelty" look that was also fully compatible with the spirit of "scholar autonomy ", the hearth of the reform that will

produce a radical change in the Italian school system. This is how two teachers summarise their idea on this point thus expressing the opinion of most teachers participating in the experimentation

> *Finally, we got to breathe "new" air during the training course and while working in the classroom.*
> *The students were very enthusiastic about this initiative (this is what comes out of a little survey done at the end of the course). They agreed that it was a useful experience for every one of them. The more performing students because, in addition to their own acquisition of knowledge, they felt involved in helping others, (besides having to work more to keep up with their reputation of good student), the students having usually more difficulty were helped and stimulated by others; the lazy students because they did not slow the work of the others and did not look too bad they were stimulated to get involved more and to work seriously. The outcomes of this were confirmed in the final mathematics test that was very satisfying.*

Reading the records of the experimentation, in the section where were noted the facts, the reactions and the most relevant episodes, according to the teachers, it is possible to feel the climate of the classroom and gather some very sympathetic anecdotes. Here are the words of a student about the mode as the teacher reports them after the lesson on the central tendency measures:

> *Who is "di moda[1]" is not original*

and also the observations of another teacher on the reactions of her classroom during the lesson on the same subject.

> *the computation of the median involved lot knowledge from a statistical point of view. The concept was "greatly appreciated" (at their age, they like to divide things in "black" and "white"!!). The arithmetic mean "lost" a lot of its "fascination"!!*

And another sympathetic episode that gives a measure of the involvement of the students:

> *A student from another class came in the classroom to ask about their availability to answer a questionnaire on bohemians (without further precision); she was overwhelmed by demands on the "why", on the modality of the data collection, on the costs and eventual financing ...to such an extent that she finally dropped the project saying that she would come back with more information!*

Summary

A two-year research programme entitled "Experimenting New Teaching Strategies for the Learning of Statistics" has been conducted on a large scale in four Italian Regions (Lazio, Sicilia, Umbria and Veneto). About 120 teachers and 2500 pupils of the Secondary School level (principally from the third year of Technical Schools and Scientific High Schools) were involved. Specific educational material was prepared and after a specific training program for the teachers, experimentation in classes took place at the same time (March-April 2000), during mathematics lessons. The experimental activity supplied learning modules based on a "data oriented" approach which have been presented to the students using different modalities: a traditional approach (frontal lesson); a traditional approach combined with the use of computer and finally, cooperative learning with the use of computer. The work carried out up to now reveals the importance of teaching of statistics in school, at the condition that it is "correctly" implemented; statistics provides methods and instruments to read reality, which link different subjects, it provides also a concrete environment for learning and places the school in the context of everyday life.

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[1] Being "di moda" means to be fashionable>

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