

## TEACHER'S TRAINING IN A STATISTICS TEACHING EXPERIMENT<sup>1</sup> ®

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*A large experiment, investigating to what extent the use of real data and/or technology and/or pedagogical methods favour student's learning of statistics concepts, was carried out in Italy. The experiment has been monitored both from the side of pupils and teachers. This paper shows the findings from the teachers' point of view, through the analysis of their professional profile, attitudes towards statistics and opinions on its teaching before and after the experiment. The study reveals that, as teachers' training was in mathematics, they taught statistics with a mathematical approach, instead of "teaching statistics as a respectable subject" (Moore, 1992, p.14). The experiment produced a further more significant result, as it produced a substantial modification of teachers' perception of the approach to adopt for teaching statistics.*

### THE CONTEXT

In Italy, where often the teaching of statistics does not give statistics the educational role that it deserves, a large experimental research was carried out in four regions at all school levels. The research aimed at investigating to what extent the use of learning materials based on real data combined with different pedagogical methods would favour students' learning of statistical concepts (Moore, 1997). The experiment took place in the school year 1999-2000 and involved 2129 pupils and 145 teachers from primary school, 1514 pupils and 86 teachers from lower secondary school and 2500 pupils and 107 teachers from upper secondary school (Milito et al, 2001). This paper concerns the teachers' perception of the experiment carried out at the upper secondary school level.

#### *The Experiment at Upper Secondary School Level: An Outline*

For the upper secondary school level, the research group set up a course on descriptive statistics adopting an approach reflecting the applied nature of the subject and stressing its cross-disciplinary character and its educational relevance. The course aimed at making pupils able to read and interpret quantitative information and understand the meaning of statistical indexes, while providing the technical terminology and the calculation procedures. Particular attention was given to the use of real data. The course was designed to:

- help pupils understand the main features of a statistical survey;
- acquaint pupils with official data;
- develop the skills for building and interpreting statistical tables and graphs;
- develop understanding of the meaning of central tendency and variability measures.

The course was organised around a statistical survey to be carried out in class, so as to allow the students to learn statistics while working with their own data. The survey aimed at investigating some aspects of everyday life (family, eating habits, means of transport). Although not very original, the topic chosen gave the students the opportunity to work on data from official sources, as they were asked to compare their data with those from their region or the whole country. The course duration was set for 20-25 hours.

The experiment intended to explore the effectiveness of three teaching strategies, all founded on materials structured with a Data Oriented Approach (DOA): traditional teaching, allowing the students to use a pocket calculator for calculation (DOA group); traditional teaching with the support of the computer (DOA+Lab group); teaching based on the Cooperative Learning model and with the support of the computer (DOA+Lab+CL group).

The recruitment of teachers was done on a voluntary basis, even though participation from technical and scientific high schools was particularly encouraged. The allocation of teachers to the experimental groups was not random, as it was necessary to take into account the needs and the assets of their teaching. Different training schemes (from 20 to 40 hours) were implemented for the different groups. The aim of the training programs was to prepare all the teachers to use

the experimental materials thus reducing the variability due to the “teacher effect”. The teachers of the DOA+Lab+CL group all received a specific pedagogical training on the Cooperative Learning approach.

#### *Data Sources*

This paper uses a subset of the experiment’s assessment materials, those more relevant for outlining the teachers’ profile and their point of view about the experience done: one questionnaire on the teachers’ vocational experience and one on their attitudes<sup>i</sup> towards statistics; recorded interviews<sup>ii</sup> at the beginning of the training sessions; written and oral reports made after the experiment. All this data was collected at different moments. For this reason they do not always refer to all the teachers who took part in the experiment.

### THE TEACHERS

#### *Vocational Profile*

Of the 107 teachers participating in the experiment, 91 answered the questionnaire distributed during the presentation meetings. Most teachers (73.6%) had a degree in mathematics, some (11.0%) in statistics. They had many years of teaching experience on their shoulders, as 85.5% of them had taught for at least ten years; moreover, 58.2% had received training in a statistics university course or in an in-service course, 15.4% had been trained only in probability and 26.4% had no training. Almost all of them taught statistics at school (87.9%), but only 38.4% also taught inference. Of all the teachers, 86.8% were familiar with computing technology, but only 27.5% used the computer lab often and in such a case they mainly worked with spreadsheets.

#### *Attitudes towards Statistics*

The attitudes questionnaire (103 responses) revealed a positive attitude towards statistics. On the whole, teachers found statistics easy to understand (55.9%); they found that statistical reasoning is useful in everyday life (74.0%) and that statistical information is important for building opinions and making decisions (93.7%). They believed that knowing and using statistics is relevant for the students’ whole intellectual development (68.7%). However, when asked whether time for statistics should be found at the expense of maths, they were doubtful (35.3%).

The positive attitude shown is not surprising: most of the teachers taught statistics (at least descriptive statistics) and they felt it gave no particular problems; they had chosen to participate in the experiment, so they were interested and motivated. The sample was clearly an auto-selected one and it could be interesting to verify whether a random sample of teachers would share the same opinions and beliefs.

### THE TEACHERS’ OPINIONS BEFORE THE EXPERIMENT

The interviews made at the beginning of the training provided further information on the teachers’ profile that had emerged from the questionnaires. All the participants answered to the interviews willingly, showing a desire to talk about themselves and to let others know about their thoughts. We shall refer here to the answers given to two of the questions posed:

- What are the interesting aspects and what are the problematic ones in the teaching of statistics?
- Why did you decide to participate in the experiment and what do you expect from it?

The vocational experience questionnaire already showed a weak relationship between the experience of teaching statistics and the preparation on the subject, as most teachers taught statistics regardless of their mastery of the discipline. The interviews revealed some paradoxical cases; for instance, of two teachers with a statistics degree, one declared that she needed to see how to put into practice the theory she had learnt, the other that she had been assigned to classes where she had very little statistics to do.

*Having a degree in statistics, I would like to be able to apply it to real contexts...this is the point...because having studied it theoretically, I’m interested in seeing how what I learnt can find application in teaching.*

*To answer the first question, maybe I could say that I graduated in statistics, so as soon as this opportunity arose I came to this course...I have to say that I teach in a high school*

*specializing in commercial studies and for a variety of reasons, like teacher placement, unfortunately I have always taught statistics very little.*

The teachers with no statistical background, “forced” to teach statistics by the school syllabus, did not go very far in their self-preparation, as they attained it directly from school textbooks. The request to teach something which is not well mastered generates apprehension; nevertheless, most of them were, maybe naively, enthusiastic.

#### *Aspects of Teaching Statistics That Teachers Enjoy*

The interviews confirmed the positive feelings towards statistics and its teaching as already seen in the attitudes’ questionnaire. Statistics was described in a variety of ways: important, indispensable for the citizen, interesting, arousing pupils’ creativity, awakening curiosity, motivating, and most of all, stimulating. The strong adhesion of statistics to reality, the opportunity to encounter statistics in everyday life and the concreteness of the subject are, in the teachers’ opinion, the strongest cards. The teachers also said that statistics helps develop a critical view of reality and makes pupils aware that the uncertain can be measured. It has been remarked that, when students are asked to construct a statistical table or a graph, they can see how to build up information from a mass of apparently unrelated data.

*The pupil sees immediately the evolution of many unrelated data, when the data are grouped in a certain way, and he can see something he couldn’t see before; well, ... this is for me the most interesting aspect, and I don’t think it can be problematic, if the pupil is assisted.*

Some teachers underlined the usefulness of statistics in the teaching of mathematics, for it allows seeing practical applications of maths, while others pointed out the interdisciplinary characteristics of statistics. *“The most stimulating aspect for my subject ... I teach mathematics and physics ... is that I can use data collected in the laboratory experiments, or data from some school surveys”*. *“Indeed there is also the possibility to use statistics in the computer lab, and so to use information technology in an active and clever way”*. It is interesting to see that a few teachers not only considered statistics as different from mathematics, but they also saw this as a positive aspect of statistics.

*Surely it has a great educational value, because it is very open, very free, it is a free way of learning and also it contextualizes mathematics, which is often difficult to relate to real-life contexts; I meant that it is difficult to make the students realize that maths is near to their needs and interests.*

One teacher clearly declared to be curious and stimulated (*“I find that I become curious myself because of the creativity that this subject can promote”*); another said that when he taught statistics he was less formal (*“the most stimulating aspect is that I can abandon the schemes in which I am somehow confined in other classes when I deal with strictly mathematical contents”*).

#### *Problematic Aspects of the Teaching of Statistics*

Mathematics dominates statistics not only because it is generally taught as part of mathematics, but also because of the mathematical background of the majority of teachers. Reflecting this, one major problem for the teaching of statistics was reported to be the lack of time. Statistics being only a “slice” of the mathematics syllabus, *“unfortunately it is where we cut more, because it’s not so strongly linked with other mathematical topics”*. It is felt that there are more relevant things to do to prepare students for the final examinations: *“teaching statistics requires much more than the time we are willing to devote to it”*.

The second problem, the vocational background of the majority of the teachers, comes clearly into view from their perceptions of the problematic aspects of the teaching of statistics. As a matter of fact, whether they related the teaching difficulties to themselves or to the pupils, it is apparent that the core of the question is the substantial difference between the statistical approach and the mathematical approach.

From the students’ angle, in general the teachers felt, apart from a few exceptions, that descriptive statistics does not pose particular learning problems. When difficulties were reported, they seem to be the typical problems that arise when statistics is taught in a mathematical fashion, placing more emphasis on formulas and computations than on the interpretation of the results.

*I tried different ways ...but it has been a failure...I saw that the students were not interested, perhaps because of the formulas, this is why I say ... for me it was only formulas ... statistics ... it was my nightmare.*

*Difficult...well, it depends on the level at which it is taught; with descriptive statistics the computation difficulties could be easily overcome, also for the possibility of having the computer perform the calculations. But at a higher level ... with inference... things get awkward, because there are many more difficult concepts involved*

Some of those who saw descriptive statistics simple for pupils to learn even said that it could be dull for the most brilliant students. *“There are very few prerequisites, so there is the advantage that also the students who are handicapped ... mathematically speaking ... are at ease. Statistics is different from maths...students that love the abstract aspect of mathematics, the skilled ones, they do not appreciate statistics”.*

Only a few teachers mentioned the difficulties that students might have in learning to “think statistically”, as it happens when they are asked to process data to extract statistical information from them. Statistics is a mathematical science but it is not a branch of mathematics. It has its own modes of thinking that are more fundamental than either specific methods or mathematical theory (Moore, 1992). In Gal and Garfield (1997), statistical reasoning is seen as distinguished from mathematical reasoning for a variety of reasons, one of which is that many statistical problems do not have only one mathematical solution. Often, problems start with a question but ask more for an opinion based on findings and assumptions. The end point is not to judge as “right” or “wrong” the conclusions or inferences presented by the students. They have to be evaluated in terms of quality of reasoning, adequacy of methods employed, nature of data and evidence used (Gal et al, 1997). In that respect, it is worth reporting two interesting answers that show how well the teachers who gave them were aware of the problem.

*Problematic...making them acquainted with working by approximation...when the figures have to be rounded they are upset ...sometimes they try to adjust things to make the result exact as they think it should be.*

*I think there are two kinds of problems that the students feel. First of all, it is the method we adopt...We switch from deduction to induction, that is we shift their ground. The second problem is not having the certainty of mathematics ...when a function is given, perhaps even the weakest goes on ...pitipà...pitipà...he does the job. In statistics we say 'no, dear, you have to decide which average to choose according to the problem', and he will be terrified.*

Other teachers showed their sensitivity towards the need for a different approach in the teaching of statistics by recognising themselves as not being able to adopt one. Obviously, their self-training in statistics did not provide them with a good methodological support for teaching statistics.

*There is the problem that it is a different way to work for us...that is, we have always cared more for an aspect of mathematics...Consequently, we work better with probability, but with statistics the work is more difficult.*

The problematic aspects of the teaching of statistics being reported give much to think about the teachers' perceptions of the teaching of statistics and also of mathematics. Descriptive statistics does not seem to be a problem, since the mathematical tools are simple; inference is considered more interesting, but difficult to learn, as there are many not easy mathematical concepts in it. It is worth mentioning, as aside information, that the teachers on the whole would have been happier to experiment a course in inference. In a certain sense they “took on” the demand of experimenting a descriptive statistics course. During the training sessions, however, they started to realize that descriptive statistics had been undervalued, as it requires the ability to make inference, a prerogative that they had assumed belonged only to statistical inference in a “strict” sense.

In conclusion, the answers given to the question on the interesting and problematic aspects of the teaching of statistics raise several queries. The concrete aspect of statistics and its cross-disciplinary nature are considered valuable qualities for students' mental growth. Unfortunately, however, teaching statistics requires a considerable amount of time, which would be subtracted from other mathematical topics that are felt to have very little to do with statistics.

The nature of statistics encourages an approach less rigid and formal than in mathematics, which is recognised by some teachers as more suitable for the learners' age, while others fear that, just because of such an approach, statistics might not be interesting enough for the pupils who are most brilliant in mathematics. On the whole, the interviews reveal a feeling of insecurity, due not so much to lack of preparation in statistics, but especially to lack of preparation in the teaching of statistics. It is natural at this point to analyze the teachers' motivations as regards experimenting a new approach for teaching statistics. This will help us understand the teachers' expectations about the experience.

#### *The Teachers' Motivations and Expectations*

The second question in the interviews regarded the reasons that made teachers participate in the project and the results they expected from the experience. Words that frequently recurred in the answers were "curiosity", "interest", "collaboration" and "need". Teachers were driven by the curiosity of knowing new teaching methods (*"the main motivation is to see these new methodologies both from a didactic and a pedagogical point of view"*) and by *"the possibility to make a concrete experience, at last, with real data to process"*. They wanted to see how statisticians work and why their methods differ from the mathematicians' ones. The prospect of collaboration was another important motivation, as the experiment could allow to *"share the experience with the colleagues"* and to *"be in contact with university"*. Overall, what emerges is the demand for instruments and materials that could make statistics teaching effective and practicable. *"I'm interested in finding someone that teaches how to teach statistics and in having some materials to use in class"*. *"I hope to find answers that I need to give to my teaching, answers and indications both about content and method"*. *"As the time I have is not much, I expect to find methods and materials to spend easily"*.

To sum up, the teachers' motivations and expectations fell in two categories: in the first there were interest, curiosity and the wish to improve one's teaching; in the second, need of collaboration and help; the latter could be explained with the feeling of loneliness that often teachers experience in their work and by the poor didactic preparation in teaching statistics. As for interest and curiosity, one can only be glad to see "old" teachers still showing a desire to learn and to improve the quality of their service.

#### THE TEACHERS' EVALUATION OF THE EXPERIENCE

The experiment was monitored through a diary that the teachers were asked to write. Also, meetings were organized to hear the teachers' final impressions. In the meetings, discussion focused on experimental materials and methods, pupils' reactions and repercussions of the experiment on the profession. The results presented here derive both from the written reports and the discussions. In general, the experiment was evaluated positively, also in consideration of the students' active participation, *"because they did it willingly, and the families always reported to me on the enthusiasm with which they would do the homework"*. A few teachers found Cooperative Learning an effective pedagogical method, since *"it has been useful to all: the most capable students were not only stimulated to learn more to confirm they were the best, but also took responsibility for helping the others; the weak students could be helped in many ways; the lazy students were stimulated to work so as not to slow the groups' pace"*.

Other teachers, instead, found the CL method too demanding, for it requires a long preparatory work. The combination of DOA with lab activities was found *"winning"* as *"students were able to give a sense to the figures, could learn the formulas with the help of Excel, when asked to compute the mean, the median, etc. for grouped data; moreover, for the presentation of the results they had to face the problem of rounding"*. Some difficulties were found, however, in the practical organization of lab activities.

The course materials, all based on DOA, were largely appreciated because *"they made it possible to set up very well organized lessons and made us think about the method to follow to develop each teaching unit"*. However, the materials were written as a guide for the teachers and not as a textbook. Many teachers missed a written support for the students' individual study, as the textbooks adopted showed to be not in line with the approach experimented. The experience was considered positive from the professional side, as teachers believed they had achieved an

appreciable professional growth. It is not irrelevant to mention, as a final remark, that the experiment produced, in most teachers, a different attitude towards descriptive statistics. The following comment of a single teacher is actually a widely shared opinion.

*I learnt many things that for sure will be useful in the next years, when I shall find myself again facing the task of teaching descriptive statistics. I think that, on the whole, perhaps this is just what you wanted!*

## CONCLUSIONS

The experiment aimed at assessing the effectiveness of new strategies for teaching statistics in promoting the development of pupils' statistical reasoning. The study done here shows that, despite the previous experience in teaching statistics that the majority of the teachers had, the experiment produced on the whole also a substantial change in the perception of the style of teaching to be adopted for effective learning to take place. This could be explained by considering that the teachers' statistical background, when present, derived mainly from in-service training courses which, most likely, had no effect on modifying their approach, when facing the task of teaching statistics. As their vocational training had strong mathematical grounds, they taught statistics with a mathematical approach, instead of "teaching statistics as a respectable subject" (Moore, 1992). It was while the teachers were carrying out the experiment that they became really aware of the need of a different approach.

A collaborative way of working with teachers was implemented, which turned out to be for them a valuable form of training. Training courses often have a rather theoretical character, leaving to teachers the task to put into practice the knowledge they acquire. In general, teachers cannot benefit from some kind of feedback from their trainers, nor from devices encouraging collaboration amongst them because the training programs do not provide such options.

It should be remembered that the experiment, carried out at all school levels, entailed training of all the teachers involved in it. Although it has here been reported in some detail what the training and the subsequent experiment implied for the upper secondary school teachers, the overall conclusions are not so different from the ones coming from other school levels. All that reinforces in us the idea that new training strategies should be explored, in order to make the training really effective in developing teaching styles appropriate to statistics.

<sup>i</sup> The attitudes questionnaire was adapted from SATS by L. Brunelli, University of Perugia, and M. Marsala, University of Palermo.

<sup>ii</sup> The structured interviews were prepared and made by S. Casucci and M. Striano, both pedagogists of the University of Perugia. The transcriptions are due to M. Striano.

## REFERENCES

- Gal, I., & Garfield, J.B. (Eds.) (1997). *The assessment challenge in statistics education*. Ohmsha: IOS Press and The International Statistical Institute.
- Milito, A.M., Rigatti Luchini, S., & Pannone, M.A. (2001). New strategies for teaching statistics at school. In *Proceedings of the 53<sup>rd</sup> Session of the ISI* (August 22-29), Seoul, Korea.
- Moore, D.S. (1992). Teaching Statistics as a Respectable Subject. In F. Gordon and S. Gordon (Eds.), *Statistics for the twenty-first century* (pp. 14-25). Washington, DC: The Mathematical Association of America.
- Moore, D.S. (1997). New Pedagogy and New Content: the case of Statistics (with discussion). *International Statistical Review*, 65(2).