

MATHEMATICS FOR LIVING
THE MATHEMATICS EDUCATION INTO THE 21ST CENTURY PROJECT
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**TEACHING STATISTICS AT PRIMARY AND
SECONDARY SCHOOL: AN ITALIAN RESEARCH***

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***Abstract:** This paper is about a research involving 170 teachers and more than 3000 pupils from primary schools (6-10 years old) and 86 teachers and more than 1000 pupils from secondary schools (11-14) in Italy. The research at primary school proposed statistics units based on the Data Oriented Approach (DOA) arranged in different classes according to two distinct didactic strategies. Firstly the didactic model oriented to objectives, and secondly the model oriented to a connected understanding represented as a map of connected concepts. As far as the teachers were concerned, they were all provided with an in-service training on statistics, pedagogics and the theory of learning. The semi-structured class interview was the tool used to point out a connected understanding of Statistics' basic concepts. The rationale of the experimentation at secondary school is that learning statistics based on DOA is easier if the didactic model Co-operative Learning (CL) is used. The CL method is considered the best way of learning by responding to Statistics in University courses (Moore, 1997). We try to adopt this didactic strategy also at secondary schools. The experimental design compares the learning statistics results using CL methodology with a strategy based simply on real data.*

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1. Introduction

We report about a research involving teaching statistics at compulsory school. This research was supported from the Italian Ministry of University and Scientific Research and organised by the Statistics Departments of the Universities of Palermo, Padova, Perugia and Roma.

The main aim of this research was to evaluate the efficiency of a teaching approach based on a Data Oriented Approach (DOA). Other objectives were to explore the personal and didactic frames of teachers with regard to statistics, and to compare learning based on different methods for teaching statistics.

2. The experimentation at primary school.

One of the aims of primary school, not only in Italy, is to provide pupils with skills for describing and interpreting the world around them. Such descriptions often require the use of numbers, graphs and diagrams. In many subjects, teachers carry out researches handling data, representing them in tables and graphs, interpreting them and obtaining information from them. They are often not aware that all these activities should in fact be termed Statistics. In this case, by Statistics we mean handling data and describing the phenomena in the world around us using graphs, diagrams and numbers.

Therefore we think that it is necessary to teach Statistics in the primary school from the primary grade. This teaching has to be given in a clear subject frame and in a clear didactic frame; every teacher has to be conscious of the basic concepts and contents of Statistics he/she is teaching.

We choose the DOA approach on the hypothesis that working with real data reflecting a phenomenon of daily life favours structured learning. At first teaching grades seemed to us very important to control the concepts of acquiring more than technical uses. In other our researches we observed that pupils and teachers learn some basic notions of Statistics: they are able to collect data, to represent them, to analyse, to calculate correctly averages and so on, nevertheless they don't have the critical capacities to inspect them (Perelli D'Argenzio *et al.*, 1998). So we tried to introduce a teaching oriented to construct concept nets and not separated notions.

We attempted this during the school year 1999-2000 in five cities from North to South Italy¹. The experimentation involved 145 teachers and 2129 pupils.

Teachers had an in-service training for 32 hours, the contents of which are as follow:

- basic concepts of statistics: handling data, data collection, stem and leaf plots, tables representation, graphs, means and elementary concepts of variability. Simple elements of how to analyse critically data and how to inspect them to obtain true information and how to perceive the validity and the meaning of data averages.
- psychopedagogic elements linked to the statistics contents teaching at primary school.
- concept maps model: concept map, semi-structured class interview, concept net.

Teachers received teaching units to follow in the classroom: on the left sides the material contained the unit for the pupils, the right sides contained hints for the teachers, possible teaching problems which might arise at this point and possible variations of tasks. The teaching units were prepared for three levels: 6-7 years, 8-9 years, 10 years.

¹ Treviso, Pordenone, Perugia, Palermo and Oristano.

Many ideas of the teaching units derive from Pereira and Dunkels (1991) and Dunkels (1999). The evaluation tests were prepared for five levels: one for each grade. In the classes involved with concept maps, teachers had to perform two class interviews: one at the beginning of the statistics activity and one at the end, to compare the ideas that pupils had developed.

We considered particularly interesting the problem of representation, which involves four main phases. Firstly the manipulation of raw data drawn from pupils; consequently the collection in a disorderly way; thirdly the representation in an arbitrary way and, finally, after a class discussion, the drawing of pictograms (fig.1,2,3). It is then that pupils manage to draw block graphs without using numbers and proportionality.

The first analysis of the results by comparing the achievement tests of students following the concept maps strategy with the one that followed only the DOA didactic approach, revealed to us that on the whole the results from traditional DOA teaching are a bit better than those from concept maps teaching. On the other hand, some results about more conceptual items are better from pupils that had concept maps teaching. The results of class interviews were very interesting as we may see from fig. 4 and 5.

3. The experimentation at secondary schools

The objective of this experiment involving four Italian regions² was to evaluate the efficiency of the teaching approach based on a DOA using a Co-operative learning (CL) model, compared to the classic method for teaching statistics. Another objective was also to compare the results in the four geographical contexts.

The CL methodology was chosen because of the advantages it presents particularly for learning statistics and for the good results obtained in other experimentation (Moore, 1997).

The DOA approach is based on the hypothesis that working with real data reflecting a phenomenon of daily life, favours a better learning of statistical methods, and develops students' interest as they are personally involved in the collection and interpretation of data. Moreover, this methodology contributes to the development of critical and explanatory capabilities that, if we don't consider the formal aspects of the subject, represents the real difficulty of studying statistics.

The CL methodology is based on collaborative strategies since the relationship between students is considered. Students, working in pairs or in little groups, develop co-operative behaviours receiving group or individual evaluations. The teacher's role is to guide the classroom and to prepare the teaching contents and material after increasing students' social-relationship' abilities which is a prerequisite for the efficacy of this methodology.

The experiment design provided the involvement of the teachers in four regions. The teachers were selected in different ways according to the regions. In Umbria and in Veneto, the teachers involved in the project were those who had already participated to previous training courses organised by CIRDIS³ or other institutions. In the two other regions, teachers were chosen through a questionnaire submitted in the schools randomly selected. After the first explanatory meeting on the procedures and schedules of the experiment, the teachers' agreement was gathered. The selected teachers followed an in-service training in two different periods (first in September-October 1999 and the

² Sicily, Lazio, Umbria and Veneto

³ Centro Interuniversitario di Ricerca per la Didattica delle Discipline Statistiche.

second in February 2000), the first on basic statistic topics for secondary school level and the second to study the CL methodology. At the beginning and at the end of the training course, the teachers responded to a Measuring Scale regarding Statistics, in order to analyse their mental attitude and their educational-value given to Statistics. The hypothesis was that their efficacy for teachings statistics depended on their attitude. Also, we wanted to evaluate changes in this attitude explained by the training course experience. Another purpose of the training course was to standardise the teachers' behaviour in order to bring certain uniformity to the experimentation in the classroom.

The table 1 presents the number of teachers and the students involved in the different parts of the experiment. About 26% of teachers who showed some degree of interest at first, were absent at the following meetings; some because they were already involved in other classroom⁴ experimental activities, others because they weren't really interested in the proposed experiment. The teachers who took part at the training course included those (about 31%) who did not teach at the level where the experiment was to be done. The research team, in fact, had decided to limit the trial only at the last year of the secondary school because of the students' age, and the basic prerequisite knowledge. The classroom experimentation was developed to last 18 hours for teachers following only the DOA approach and 20 hours for the ones using also CL.

Table 1: Teachers and students at secondary school involved on experimental project according to the Regions.

Regions	Teachers					Students
	Interested at first	Participants at training course	Participants at experimentation			Participants at experimentation
			DOA	DOA+ CL	TOT	
Sicily	41	35	10	8	18	342
Lazio	23	23	12	11	23	340
Umbria	66	38	12	14	26	572
Veneto	38	28	7	12	19	378
Total	168	124	41	45	86	1632

The research team, composed of statisticians and psychologists, prepared the material for the teacher training and for the experimentation in the classroom. In particular, teachers received a bibliography of statistic books used in Italian universities; a glossary containing statistical terms and other material with statistical contents presented in the training course. The teachers interested to the CL methodology also received a book on this matter. Every teacher in the second phase received teaching units to follow in classroom subdivided by content, previous objectives with indications on the prerequisites and the time necessary.

The content was limited to descriptive statistics and was divided into five categories:

- 1) questionnaire and data collection;
- 2) tables representation;
- 3) graphics;
- 4) means;
- 5) variability.

⁴ Only teachers free of others experimentations are chosen.

The decision to exclude some probability concepts, even if it was included in the ministerial programs, has been taken by considering the teachers who chose to limit their efforts in classroom even if probability rises the students' interest.

In the 86 classrooms, the experiment started on the 1st of March and finished the 20th of April 2000. During this experiment teachers filled a daily or weekly diary specifically on the experience in classroom. This seems to be an essential instrument to understand the difficulties of this experience in the single classroom in order to reduce the teacher effect in the evaluation process of the whole experience.

With regard to the students, we supposed that an increase of logical capabilities (reasoning, classification capabilities, causal relationships, etc.) depended on the study of basic elements of statistics. So, an experimental test, called MAST, was submitted to the students. MAST is formed by a collection of other devices and has been created *ad hoc* by psychologists belonging to the Palermo research group. This instrument has been submitted at the beginning of the experimentation and at the end in order to evaluate the change in logical capabilities. For the efficiency of CL methodology, it was necessary that students develop basic social-relationship capabilities. So, at the start of experimentation and only for students of CL strategy, two instruments have been submitted: 1) The Children Social Relationship questionnaire (RS)⁵ and 2) the Children Assertive Behaviour Scale (CABS)⁶. At the end, an achievement test to evaluate contents was also submitted.

The statistical analysis of the results will compare the achievement tests of students following the CL approach with the ones that followed only the DOA didactic approach, considering also the geographical context. In addition there will be an analysis of the causal relationships, if any, between the statistical contents learned by students (achievement tests) and the students logical-understanding ability (through CABS and RS); and a speculation on the change of logical capabilities (MAST in t1 and t2 time).

The statistical analysis of the results above described is going on. At the end, the research units will adopt other statistical methods in order to individuate a model or a modelling system to study the relationship between the teacher's effect, the geographical contexts, the students background and so on.

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⁵ Italian adaptation by P.E. Tressoldi

⁶ Italian adaptation by Di Nuovo

Perelli D'Argenzio M.P., Rigatti Luchini S., Moncecchi G. (1998), Some Psychopedagogical Aspects of Introducing Basic Concepts of Statistics at the Primary School, *Proc. 5th Int. Conf. on Teaching Statistics*: 1303-1309, Singapore, 21-26 June.

Figure 1: A disordered representation of the preferred sports of pupils 7 years old.

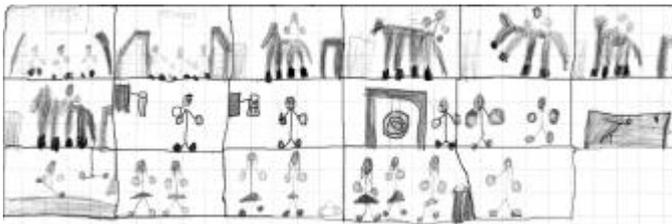


Figure 2: An ordered pictogram made from pupils 7 years old.

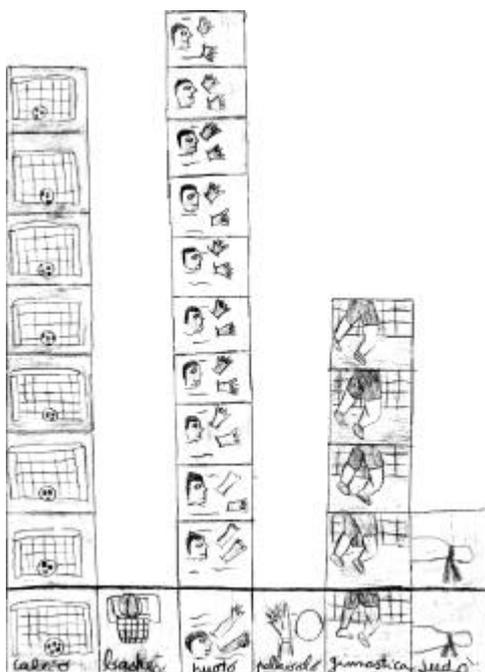


Figure 3: An ordered pictogram made from pupils 7 years old.



Fig. 4 Entrance cognitive map

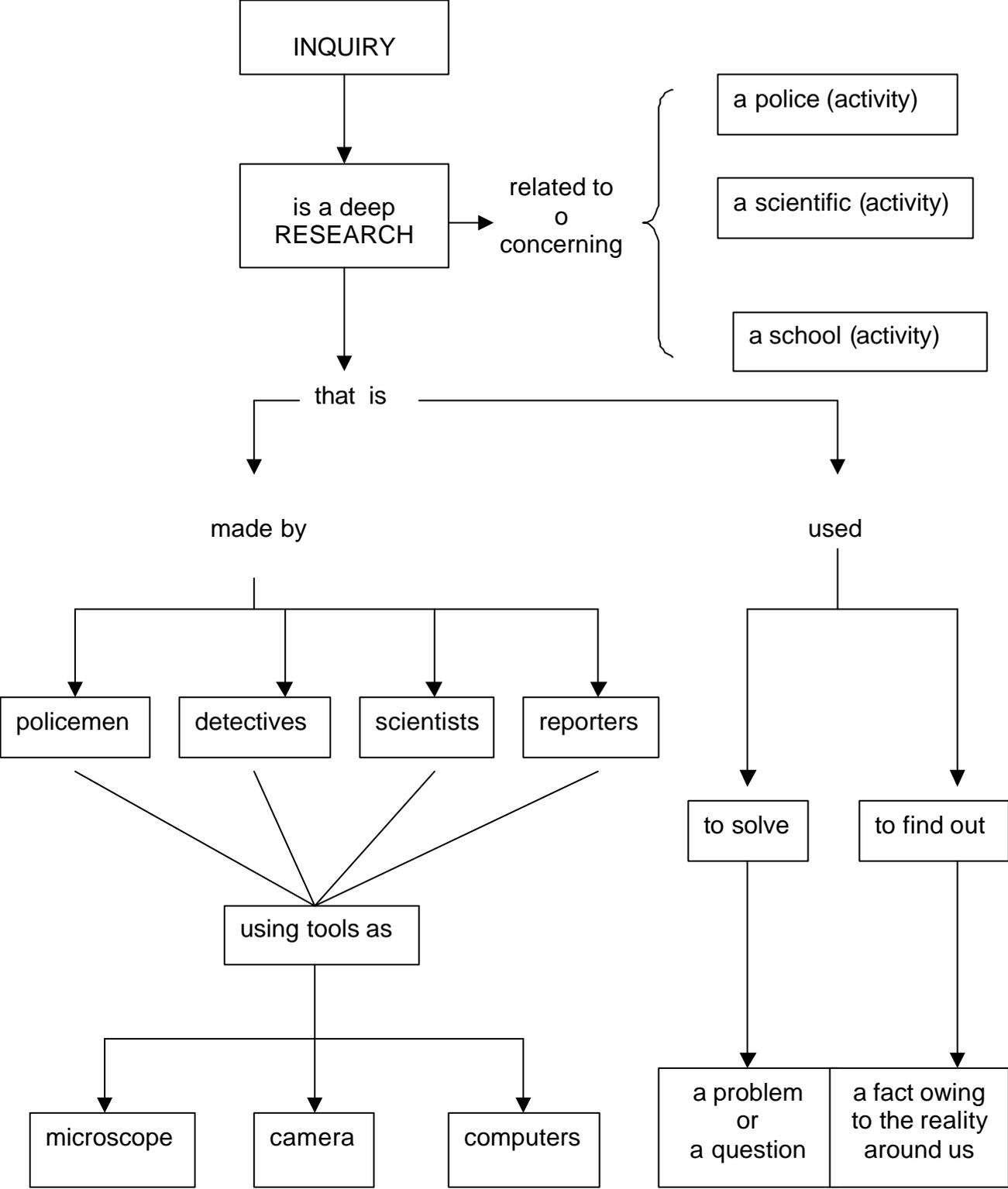


Fig. 5 Exit cognitive map

