SOME PSYCHOPEDAGOGICAL ASPECTS OF INTRODUCING BASIC CONCEPTS OF STATISTICS AT THE PRIMARY SCHOOL

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The aim of this work is to present a few ideas on teaching children the initial basic concepts of statistical knowing and related problems. To date, studies on the teaching of basic concepts have generally been concerned more with the intrinsic aspects of the concepts themselves than with the problems connected in understanding them.

At first we analyse the difficulties linked to the identification of the statistical datum from a psycopedagogical point of view, then we present the problem of misinterpretation of statistical information linked to the tendency to re-attribute synthetic values to single statistical units. Both considered aspects are objectives of mathematical programs of the Italian Primary School (age 6-10).

STATISTICS IN ITALIAN PRIMARY SCHOOL.

The primary school syllabus of Italy introduces contents of basic statistics and probability. The school syllabus reveals a tendency towards presenting and diffusing statistics not only for its own sake, but also as a way of understanding non mathematical disciplines better and of organising knowledge in all the sciences, like natural sciences, having an aptitude to vary.

This syllabus give to statistics an increasingly important role in studies and in society but it does not explicit attention to the abuse of statistics and to the capacity to judge data and to perceive the real meaning of synthetic values.

So we observed a sample study (Canato G., Rigatti Luchini S., 1996) about teaching statistics in primary schools (531 teachers interviewed)

This study gave some information about teaching Statistics:

- teachers like to have an in-service training about these contents: about 80% of the interviewed;
- they think to know enough the contents (also if they never studied in the curriculum!);
- they understand the importance of introducing statistics in the primary school: about 85% thinks that it is important or very important to introduce Statistics contents;

- they think that difficulties are linked only at the technical problem of items i.e. graphs and tables are considered easy, difficult averages.

We may note also that teachers know statistics basic concepts from a theoretical point of view, their graduation of learning difficulties is closely linked to the intrinsic difficulties, but they are not aware of the difficulties linked to the deep perception of the concepts connected with the psychological intellectual development. But only the deep perception of concepts may become structural acquisitions that construct a knowledge joined to the life of pupils and not seen as an only school activity.

We have many studies about the learning of mathematics and probability concepts (from the fundamental one of Piaget to Fischbein, Kapadia, Hawkins, Sainati etc.) but we have not the same about Statistics.

PRELIMINARY QUESTIONS

We may consider Statistics as " the methodology for the collection, presentation, and analysis of data, and for the uses of such data. Unless data are accurate, properly presented and correctly analyzed, they may be dangerously misleading. Since we are all "consumers" of statistics, it is important for all of us, not only professional statisticians, to acquire some knowledge of statistical methodology". (Neter J. et al., 1982).

From this definition we see that tools of teaching statistics in primary school is to collect data, to organize them, to calculate averages but the most important tool to be grasped is to analyze critically them, to inspect them and to perceive the validity and the meaning of data and averages. As we have seen, basic concepts in Statistics are: Survey, Population, Unit, Variable ,Data and Data set. We have also Sample survey but in our research this concept had a marginal role because it doesn' t belong to the primary school programs.

We noted that many pupils, and teachers too, have fallacies in statistics in the common life. They may become very good to calculate averages, to analyze data set, to calculate the deviations from the mean etc. but they don't have critical capacities to inspect them . So we decided to analyze the epistemological difficulties about basic concepts and we tried to overcome them with a different type of teaching. The teaching problem is not only some kind of pedagogical methodologies, i.e. problem solving, problem posing etc., but to understand the intellective difficulties and to try to overcome

them . In this pedagogical view we constructed at first a concept map about statistics, then we had some "clinical conversations" in 15 classes and -at last- we constructed some "concept nets". These nets consider the difficulties and misconceptions pupils have and operate following the intellectual development children have.

TEACHING THE BASIC STATISTICAL CONCEPTS

The first step in understanding statistics is to identify the *population* being investigated and the corresponding *statistical units* it comprises. In primary school terms, this first step presents none of the difficulties of genuine research, because the type of investigation selected by teachers must be simple and must deal with easily identifiable, not too numerous, finite universes.

The next step is to identify the *case* and the statistical *datum*. This datum has been clearly defined by the experts in terms of its intrinsic characteristics (continuous or discrete quantities, more or less easily distinguishable attributes, etc.), but the psychopedagogical problems in entails have been far less generally acknowledged. The process by which a datum is created as certain aspects which are not easily perceived by primary-school children: in particular, the type of abstraction views the statistical unit *not as a whole* but as an *anonymous element* lacking any feature or characteristic other than the one we are interested in. This type of abstraction is particularly difficult at primary-school age, which is a time for practical operations, not for formal reasoning; moreover, the child's intuitive faculties, which are essential to learning, typically take an all-inclusive rather than an analytical outlook.

It is therefore important to help the child understand that, in the process of abstraction, the feature being dealt with is of interest in its own right, separate from all the other features which form a part of, and are combined together in the statistical unit.

At the age considered in this study, it is also particularly difficult to understand that in observing certain features of each statistical unit, the intention is not evaluate those features, but rather to draw conclusions about the presence of those features in the population as a whole, because statistical study aims to provide information on phenomena concerning the group not the individuals.

Teachers may help pupils to overcome these difficulties making them conscious how every observation examines various aspects of each unit under inquiry and then don't consider all those aspects that are not useful for the objectives of the study. In

Geometry, for instance, if we consider a object square formed and of which we are interested about the perimeter measure for some else practical problem, we don't consider the colour, the material, the weight, but only the length of the side.

To be aware that, in a very concrete situation, we consider only aspects useful to solve the problem we have, abstracting from all others things related to the situation of interest, can help pupils to divide the statistical characters from the statistical unit from which it come.

Another ability that the teacher has to establish, in order for the child to consciously obtain the statistical datum, is *to know how to see the alternatives* that exist in the *feature* being observed. When the feature is quantitative and the alternatives can be expressed numerically, the task is fairly straightforward because the child has grown used to the comparison between numbers in learning arithmetic; but when the observed feature is an attribute, uniformity or diversity in the alternatives becomes a complex problem which a child is not always able to solve.

THE MISINTERPRETATION OF STATISTICAL INFORMATION

After the first steps of identification the population and the statistical datum and after having handled and organised data, teachers use to introduce the arithmetic mean, the median and the mode. To calculate or to identify them is easy and so teachers are not aware to the psycopedagogical problems connected.

The most important is the tendency to re-attribute synthetic values to single statistical units. To see the reason of this misunderstanding, strongly rooted, we compare the learning of this statistical concepts with the learning of apparently similar mathematical concepts.

Learning a mathematical concept is a lengthy process which starts with observations that may appear complex, fragmented, and somewhat chaotic at first sight. This is followed by isolating a criterion on the basis of which several distinct objects can be considered "equal" among themselves but not equal to others. For instance, in introducing the geometrical notion of a rectangle, we overlook such features of an object as its colour, mass, hardness or material composition and consider only whether or not it has a particular form, which we call rectangular. We can further introduce the mathematical concept of the square by identifying a new set of four-sided objects that are at the same time equilateral and equiangular. This gives rise to a formula of equivalence

which is what ensures that all the objects considered are interchangeable in terms of this criterion. Such equivalence among four-sided objects that are equilateral and equiangular embodies the mathematical concept of the square in that these properties belong to all squares and only to squares. At this point, those properties that are characteristic of the square (in the mathematical sense) can be reattributed to all the real objects that led to the formulation of this concept.

In the formulation of statistical concepts, the first step again calls for a process of abstraction from the statistical units to statistical data and this first step is very similar to the process described above in the formulation of a geometrical concept. If, for example, we are interested in the shoe sizes of school children, we overlook the brand, type (sandals, shoes), colour or style of the shoe and consider size as our statistical datum for each child.

The similarity stops here, however: when we go on to obtain descriptive statistics, which are synthetic values derived from the entire distribution of the data, we meet with conceptual difficulties. For one thing, while the arithmetic mean of a set of measurement has a precise physical interpretation, the same cannot be said of the arithmetic mean of a set of a shoe sizes. Moreover, the synthetic quantity, e.g. the arithmetic mean, can no longer be re-attributed to each element of the population from which it was generated. In spite of that, young children (and adults too) seem to have an instinctive tendency to follow their intuition and re-attribute these values to individuals.

The child tends to personalise his experience, to refer all things to his own universe. "In media stat virtus", says the Latin proverb, and the child considers this "middle" as exactly where he stands. If he detects any contradiction between the calculated "middle" and the position derived from his experience, he becomes convinced that the statistical processing of data produces a lie and is therefore of no use.

What is lacking here is an in-depth awareness of the fact that all statistical information, be it the synthesis or the totality of a number of individual items of information, *loses its individual connotation.* Attempting to use it in characterising an individual is dangerous because it would involve a high degree of uncertainty. Proceeding with any inductive inference, i.e. drawing any conclusions from matters that are not directly observable, though their existence can be assumed, leads to the risk of error. Such inductive conclusions can only be interpreted correctly in probabilistic terms. Such people

are confronted with decision-making situations of this type almost every day, it is essential for them to be trained to do so properly at the primary school level.

The primary school, then, is not required to train statisticians and provide high technical training; it should provide the qualitative education that would enable the child to overcome common, intuitive ideas. The final objective of a basic educational program could be, for example, to create a teaching unit capable of transmitting the two following concepts.

Statistical information is directly informative in terms of the community, not in terms of single individuals. It results from a combination of individual data which are generally variable, in that data from different cases are in general different. In addition, as soon as two diverse items of information are combined, the resulting synthetic information, by itself, cannot be reliably used to draw conclusions about the single individual observations. But the tendency to re-attribute summary information back to individuals is common in adults and even more so in children, raising difficulties in understanding the meaning of statistical concepts, rather than in learning them.

The risk inherent in teaching statistics in primary schools is that the child may tend to separate the notions learnt at school (surveys, calculation of mean values and other statistics) from what he really experiences and believes. In fact, when he discovers that what he has learned does not confirm his own experience, he tends to rely with more conviction on past experience alone than on what he has "worked out" at school. He is unable to link subjective judgements and personal experience with what he is taught at school, which often leads to his accepting the theory at school (and being able to accurately calculate means, for example), but rejecting these skills for practical situations, and that means that the teaching method has failed. It is more important to implement teaching strategies designed to overcome these psychological difficulties than to provide technically valid instruction.

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