CONCEPT MAPPING FOR THE TEACHING OF STATISTICS IN PRIMARY SCHOOLS: RESULTS OF A CLASS EXPERIMENT IN ITALY[1]

[*]Silio Rigatti Luchini[2], [+]Maria Pia Perelli D'Argenzio, [+]Gianfranco Moncecchi
[*]Dipartimento di Scienze Statistiche, Università di Padova, Italy
[+]CIRDIS[3], Padova, Italy

The present work[4] describes the results of a study carried out in the 1999-2000 school year in primary schools of 5 Italian provinces, which involved 145 teachers and more than 2000 pupils aged 6-10. Teaching units adopted by teachers were based on Data Oriented Approach, according to two distinct teaching strategies. One regarded the usual teaching model aiming at objectives, and the other concentrated on the learning of relationships between concepts by using a conceptual map. All the teachers involved attended a preliminary training course on statistics, pedagogy and theory of learning. Basic statistical concepts and their relationships were learnt through semi-structured interviews in class. Concept mapping gave interesting results, especially with regards to permanent acquisition of concepts. Comparison with concepts pupils had before the teaching of statistics in class and after, was carried out with entrance and exit cognitive maps.

1. INTRODUCTION

The 1985 Italian primary school syllabus provided for basic statistical concepts to be introduced in two ways: 1) statistics as *a method* (as a part of mathematics); 2) statistics as *a tool* (related to mathematics, science and geography). A project to change both the Italian school system and its syllabus has been discussed for the past 4 years. In new syllabuses, statistics is called *Data and Previsions* and this underlines its growing importance. During the 1999-2000 school year, a study was carried out on the teaching of statistics in primary schools in collaboration with *CIRDIS* (Rigatti Luchni et al., 2000; Milito et al., 2001). Its purpose was to evaluate the efficiency of a teaching approach based on concept maps rather than a classic one. According to its authors, in primary schools it is more important to check the process of concept acquisition than that concerning technical abilities. Previous studies had already shown that teachers and pupils learn basic statistical notions without knowing they are dealing with statistics at all: they gather data, try to reproduce it in a chart, they calculate the average, and so on, but are unable to analyze and evaluate it (Perelli D'Argenzio et al., 1998). That is why the choice fell on a statistics teaching model aiming at the construction of conceptual nets rather than on separate notions.

2. DATA

Two different works are presented at ICOTS6: the present one describing the process of concept acquisition, and another (Bolzan, 2002), showing some its results.
The experiment regarded 145 teachers and 2129 pupils of 5 towns from Northern to Southern Italy (Treviso, Pordenone, Perugia, Palermo and Oristano).
Teachers attended a preliminary 32-hour training course on the following topics:

- basic statistical concepts, gathering and elaboration of data, stem and leaf diagrams, table and graph representation, the meaning of variability and related elementary notions;
- basic notions on how to evaluate data critically, how to analyze it to obtain correct information, how to perceive and describe the validity and meaning of data and means;
- elements of educational psychology for the teaching of statistics in primary school;
- concept map models; class semi-structured interviews, conceptual maps and nets.

Teachers were given teaching units to be used in class. Units (some ideas were taken from Pereira and Dunkels, 1991, and from Dunkels, 1999) were organized into 3 levels: ages 6-7, 8-9 and 10.

Teachers who adopted the concept map strategy focused on learning processes rather than the product of learning or required skill standards. Then they analyzed the pupils' ideas and conclusions through written exercises, class discussion and semi-structured interviews. Teachers started from a *psycologically structured concept map*. The map avoids *samples* deliberately,

because the purpose of the study is the *population*. For tha class activity, teachers used different maps containing children's everyday terms and experiences that could be related to basic statistical notions: giving preferences; carrying out a study, a report or a survey. Pupils had two class interviews on the meaning of words which appeared in the map of their class: one at the beginning of statistical work; one at the end. This enabled teachers to compare the ideas pupils had before statistical activity and after class work.

3. RESULTS

Teachers who worked on *concept-based* programmes found that class interviews were an excellent tool in highlighting the individual's and the group's knowledge both at the beginning and at the end of the teaching experience. The interview at the beginning of the teaching unit shows how pupils refer to their personal experience at and outside school and how further class discussion changes and completes their ideas leading to a specific knowledge which is supplemented by their real life and experience, but cannot be considered a proper knowledge yet. All children undergo positive changes after the teaching activity.

3.1. The following class interview (Figure 1) provides an example of how the meaning of the terms/concepts *survey-inquiry*[5] changes significantly for a 5th grade girl.

Initial interview	*Final interview*
1. I immediately think of a person who has done work to *find out something* on a topic; for example, if there is a murder, the police must *hold an inquiry on the suspects* and get to the bottom of the matter.	1. *Inquiry* is the way to know and see the preferences a population has.
2. *Survey* can be something like: asking the people, or, what they think about recycling rubbish and see how many people recycle it or don't; a *survey is to ask everybody's opinion*	2. An *inquiry* is linked with a survey, on the basis of an inquiry you can gather data and know something.
3. A *survey* on the way people dress, on fashion, to see how many people keep in fashion and how many don't.	3. *A way to see what is more fashionable is to draw a histogram*, a kind of quadrant of Cartesian coordinates where there is a vertical axis with the number of frequencies and below, horizontally, there is a series of columns that can go up and then down; and this shows you what is fashionable, you see it immediately, *it's the highest column*….and you see the lowest column …and you can compare.

Figure 1. An example of class interview provides of how the meaning of the terms/concepts *survey-inquiry* changes.

3.2. In another class the teaching method adopted to determine and construct nets of concepts on statistical contents was divided into three stages.

I. Interviews on statistical terms. Initial group interviews on the terms *inquiry and survey* gave the following results:

- looking for evidence in case of theft, murder, or similar;
- a kind of research you carry out among people and you try to find out information;
- inquiry can also mean research, looking for information to know something well;
- finding information in what people say;
- in my opinion inquiry means revealing mysteries: like policemen
- survey means to ask something;
- asking someone to do something.

This shows that:

- terms and experience are connected;

- there is no pre-knowledge related to the use of statistical terms;
- the term statistics never appears;
- information is rather confused;
- only one child associated the term inquiry with research, but this did not happen with the other children;
- there is semantic confusion between the term inquiry and request[6].

II. Singling out of concept terms. In the final interview on the same terms/concepts, inquiry and survey are considered as synonyms whose meaning is thorough research:

≻ you need to fill in a questionnaire, ask for information;

≻ for example the population census that will be taken next year is an inquiry because we want to know how many we are, what we do; an inquiry is to ask, to examine something closely;

≻ a survey could be a statistical survey, for example we drew stem and leaf diagrams to get information;

≻ you consider the pupils in this classroom and ask how many people there are in each family, you gather data;

≻ survey means investigate and gather data.

These remarks highlight:
- appropriate use of terms;
- appearance of the term statistics;
- connection between terms and concepts.

*III. **C**hildren's organization of concepts in nets*. Six months later, in the same class, each pupil was asked to draw a map of statistical terms he could remember, as there had been no statistical teaching since. Below are the maps drawn by two pupils. The maps show that terms introduced the previous year are all present. In one case the sequence is substantially consistent and correct, although incomplete (Figure 2). In the second (Figure 4) a straight sequence indicates the pupil's inability to draw a parallel between qualitative and quantitative patterns of character.

3.3. In another class the initial semi-structured interview was represented in the *Entrance Cognitive Map* (Figure 3). Also in this case children are far from thinking in statistical terms. The *Exit Cognitive Map* drawn at the end of class activity (Figure 5) contains not only statistical concepts and contents, but also indicates they are so strictly linked with previous experience as to incorporate it.

3.4. The following are definitions given to the term *statistics* by 10-year-old children during the exit semi-structured interview:

≻ it is a study that enables us to carry out a research on the characteristics of a population (Giulia)

≻ statistics is a science that studies people's preferences (Marco)

≻ with statistics one can estimate, after 10 years, birth and death rates of inhabitants, one takes a population census (Lorenzo)

≻ statistics is used to find out a population's tastes and hobbies, density and temperatures of a place (Ambra)

≻ statistics deals mainly with the frequency of births and registrations in different schools (Maria)

≻ statistics as a check of car accidents occurring on New Year's Eve (Valentina)

≻ statistics studies the frequency of fish in the ocean to study the extinction of a species and its natural habitat (Giulio)

≻ it is a study that takes in many fields, especially the "quality and quantity" of a survey (Ylenia)

≻ statistics finds out how many green areas our region, and other parts of the world, have (Sara)

≻ statistics is indispensable to check voters during elections (Emanuele)

≻ unfortunately statistics also establishes how many children starve to death every minute (Mario)

≻ what is the number of unemployed, of people who get married and divorce (Amedeo)

≻ how many foreigners live and work in Italy (Martina).

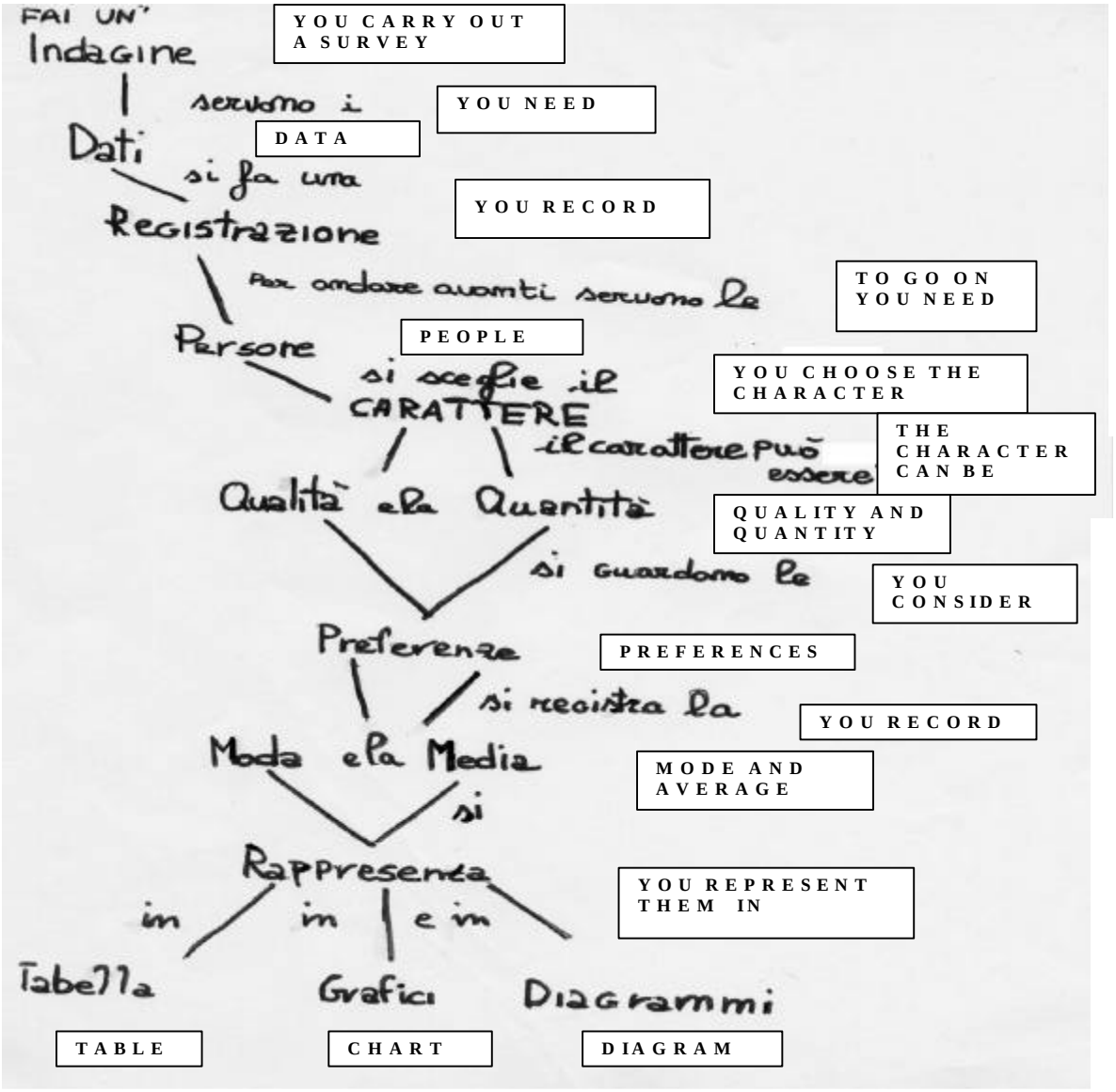

Figure 2. Correct Children's Map

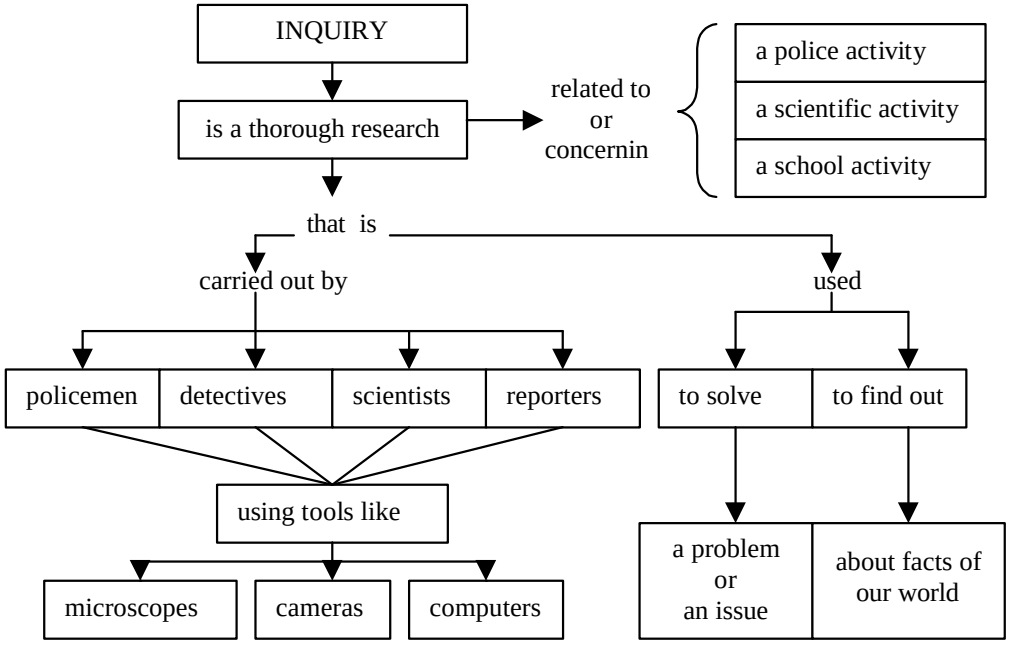

Figure 3. Entrance Cognitive Map

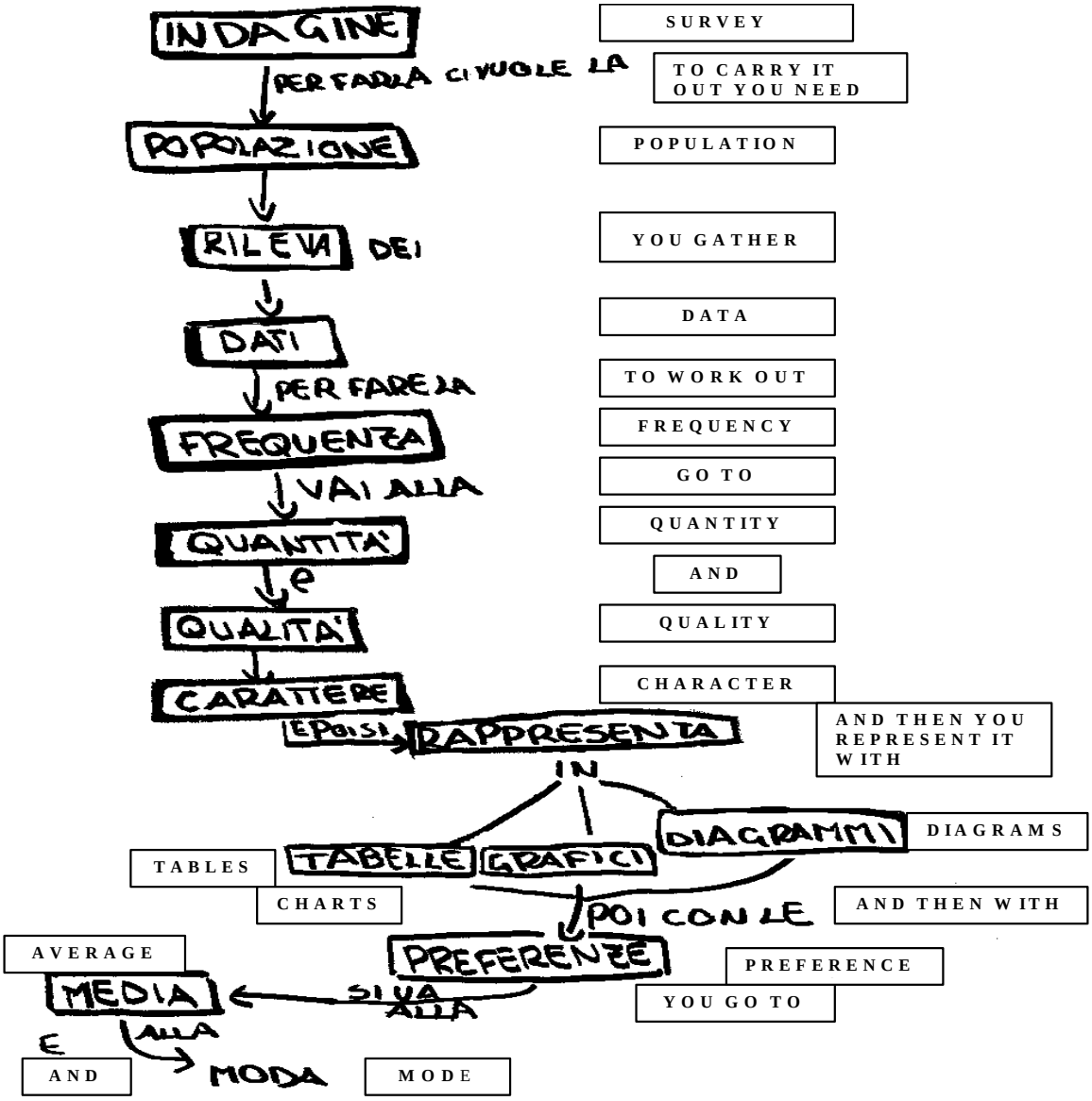

Figure 4. Incorrect Children Map

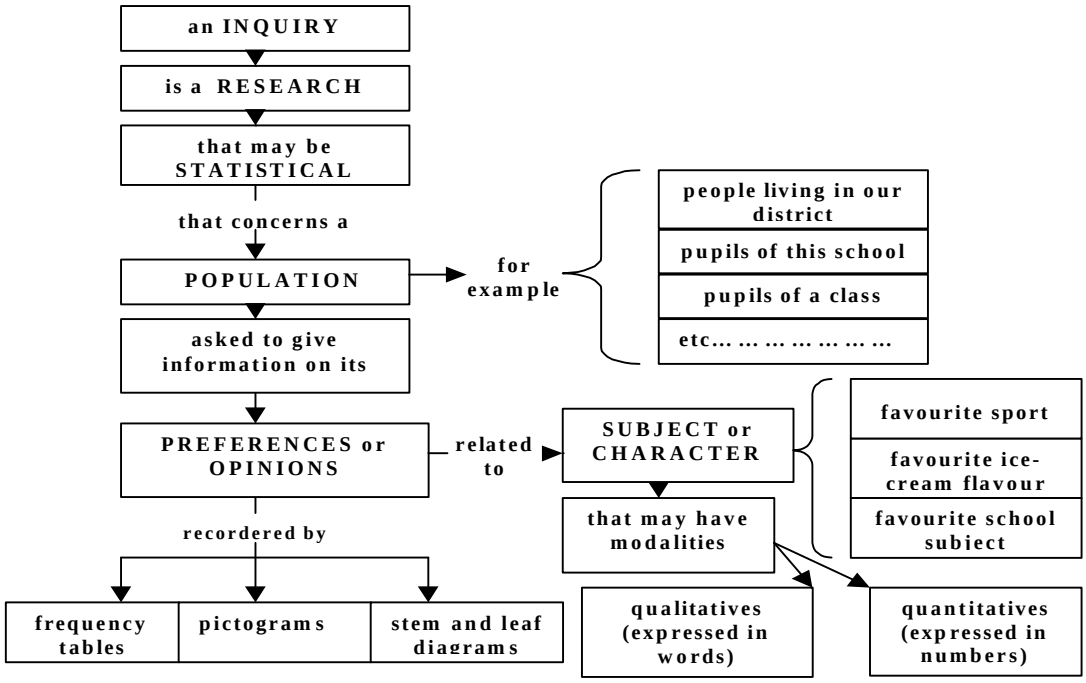

Figure 5. Exit Cognitive Map

4. CONCLUSIONS

We may conclude that, after this class activity of Statistics, children acquired competences on:

- collecting data and manipulating them, making connections between statistical and mathematical concepts and real world;
- understanding the first key-ideas of statistics, connecting them in a net (made in a childlike way) but making explicit connections otherwise implicit in instruction.

Pupils developed also some *critical capacities to inspect data* and, although in a childlike way, furthermore fundamentals of statistics have been understood from most of the pupils and embodied in them.

So this study confirm us that programs, in primary schools, should enable pupils to:

- formulate questions that can be addressed with data and collect;
- represent them at first with real and concrete materials , then with pictograms, and later in a slightly more abstract way with stem and leaf graphs or block graphs;
- organize and display data to answer them,
- use appropriate methods to analyse data and graphs,

The study tells us also that we may obtain better results if teachers use concepts nets, class interviews, and concept mapping by pupils: this didactic strategy will improve the quality of learning in a deep way.

REFERENCES

Bolzan, M. (2002). Experimental of Teaching Statistics at primary School in italy. *Proc. 5th Int..Conf. on Teaching of Statistics, Durban, 7-12 July 2002.*

Dunkels, A. (1999). Numbers, Shapes and Statistics – Triad Towards Graphicacy in the Education of Primary School Teachers. *Proc. Int. Conf. on Mathematics Education,* Cairo, 14-18 November 1999: Vol.III: pp. 62-71.

Milito A. M., Pannone M. A., Rigatti Luchini S. (2001). New Strategies for Teaching Statistics at School, *Proc. 53rd Session of International Statistical Institute, Seoul, 22-29 August 2001, Invited papers.*

Pereira Mendoza, L., Dunkels, A. (1991). Diagrammi ramo-foglia nella scuola elementare. *Induzioni*, n. 2: pp. 71-82.

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

Rigatti Luchini, S., Perelli D'Argenzio, M.P., Moncecchi, G., Giambalvo, O. (2000). Teaching Statistics at Primary and Secondary School (6-14): an Italian Research. *Proc. Int. Conf. on Mathematics Education,* Amman, 18-23 November 2000 *(electronic version).*

---

[1] This work was supported by a grant (40% 1998) of Italian Ministry of University and Scientific Research.

[2] E-mail: rigatti@stat.unipd.it.

[3] CIRDIS is an Inter-University Centre of Research for the Teaching of Statistical Disciplines that includes the Universities of Rome, Padua, Perugia and Palermo.

[4] This paper was traslated by Elena Calandruccio.

[5] The terms *survey* and *inquiry* may be easily misunderstood in Italian because a survey may be an inquiry and vice versa.

[6] *Inquiry* and *request* are assonant in Italian: *inchiesta* and *richiesta*, children can easily confuse one for the other.