STATISTICAL ANALYSIS FROM THE VIEWPOINT OF PRIMARY-SCHOOL TEACHERS AND THEIR TEACHING PRACTICE: EXPLORATIVE SURVEY OF AN ITALIAN REGION

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This paper presents a survey of the experience and attitudes of teachers regarding statistics and its teaching in Italian primary schools, and the perception of the importance of statistical culture in children's education, not only limited to the mathematical sphere, but extended to other disciplines and learning contexts. A snowball sampling procedure was used. The sample involved 300 teachers, covering the NE Italian region of the Veneto. An exploratory analysis was made of the main emerging evidence, particularly teachers' low level of preparation in the subject and its influence on teaching practice.

INTRODUCTION

There is widespread awareness of the importance of forming statistical competence in the population, especially in young generations: reading, interpreting, and informing with data are aspects of the new learning of the "knowledge society". For this reason, it is recommended to start teaching children statistical language in primary school: early statistical literacy allows the capacities for ordering, quantifying, and measuring facts and phenomena to be developed, forming indispensable abilities in order to interpret reality in a critical way and act on it consciously. Teaching statistics does not coincide with teaching mathematics, because statistics involves many primarily non-mathematical activities, such as building meaning for data by examining contexts and choosing appropriate study designs to answer questions of interest (Groth, 2007). Starting from data can help the approach to sciences and maths, mainly in cultural contexts in which scientific subjects are considered hard to deal with. In primary school, statistics should be taught as a method of knowledge which can be applied to many other subjects, instead of being only a specific subject in itself (Ottaviani, 2008; Lovett & Shah, 2007). According to the psychology of learning, especially constructivism, it is better to start this literacy earlier, before children's minds are completely organised in their essential structures (Garfield, 1995).

Statistics with probability and computer science entered Italian primary-school curricula with the Teaching Programmes of 1985. There are also rudiments of statistics in the National Directive of 2004 and the Directives for Curricula in force since 2007. The legislative document that best integrates the value and social and teaching aims of statistics is the National Directive of 2004, edited with the help of members of SIS, the Italian Statistical Society (Ottaviani & Rigatti Luchini, 2004). Unfortunately, the 2007 revision has greatly reduced these formative aims. Training in statistical competence has always been placed within the mathematical curriculum, although, in time, it has been combined variously with probability and/or computer science and/or measures and relationships. On one hand, the matching of statistics with probability shows the strong affinities between the two subjects; on the other, their position in the mathematical curriculum depreciates the importance of statistics, because statistical ideas are not mathematical in nature (Moore, 1997). However, all the normative documents reveal an awareness that statistical competence is a cross-competence, which transcends mathematics and can also be applied to many other school subjects, especially geography, history, and the sciences. Consequently, good statistical training should not only be assigned to the maths teacher, but to all the teachers who cooperate in forming critical minds. Some brilliant results of Italian experiments in this sense are reported in *Induzioni*, edited by CIRDIS, the Italian Interuniversity Research Centre for Statistical Education.

THE SURVEY

Between 2007 and 2008, 60 students in the degree course of *Primary Teaching Sciences* in Padova (which forms primary-school teachers) were involved in a survey about the spread of statistical knowledge and statistical experience at school among primary-school teachers (not only those teaching mathematics, but also all other subjects). Each student administered a structured questionnaire to five teachers of institutes in which they were training (total 300), with a snowball

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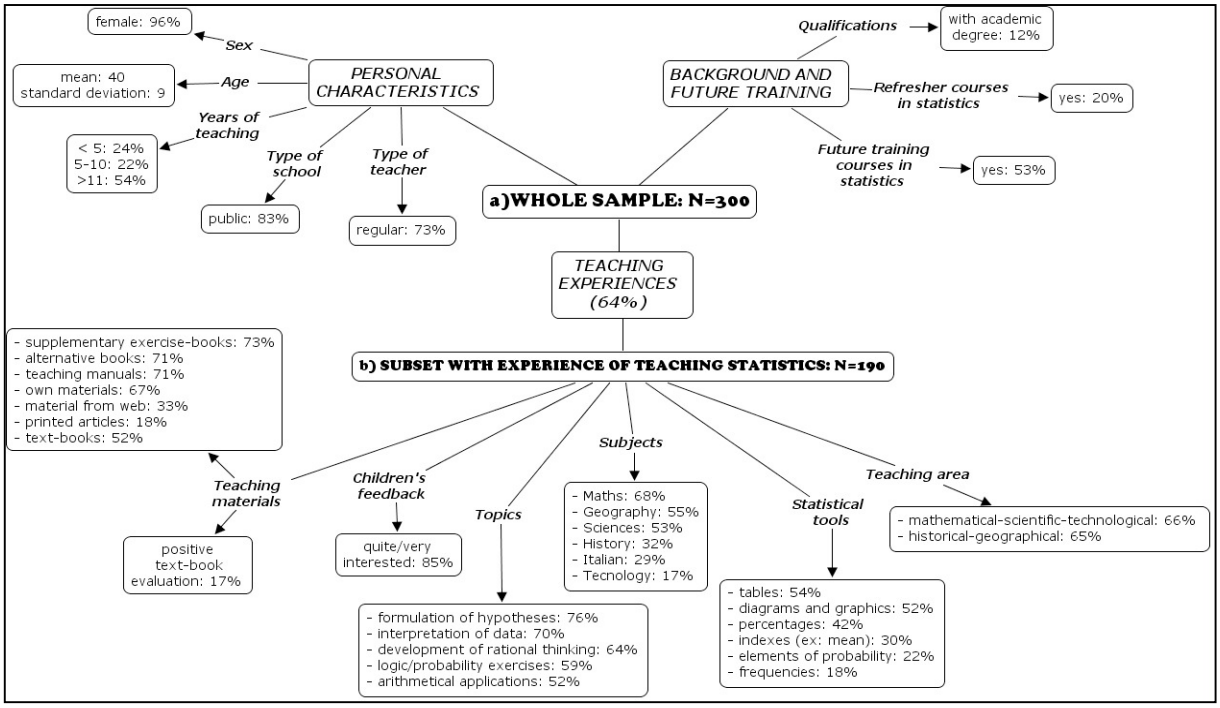
sampling procedure. The aim was to investigate experience of statistics, the importance given to it by teachers, and the formative requirements which came from working with children. The research question underlying the study concerned: *a)* the existence of a dependence relationship between teaching experience (of and with statistics) and self-evaluation of specific statistical competence; *b)* study of factors associated with teaching practice.

A total of 300 questionnaires were collected, covering the various areas of the Italian region of the Veneto. The paper questionnaire was composed of four sections covering: personal characteristics, background, future vocational training, and teaching experience. The teachers involved were mostly women, aged between 23 and 63; many of them were regular teachers; 76% had been teaching for at least five years, and most were teaching in the public sector. Only 12% had academic degrees in *Primary Teaching Sciences* (Figure 1a).

Figure 1. Summary of sample features



RESULTS

Sixty-four percent of the respondents taught subjects involving statistical analysis of data or formulation of hypotheses of uncertain facts; two-thirds of them had experience of teaching statistics in a mathematical-scientific-technological field: among those who taught these subjects, the percentage of those who dealt with statistics and probability was up to 72%. In this group, the odds ratio showed that the probability of having covered statistical subjects with children was 2.4 times higher than among the rest of the teachers.

Focusing on the 190 teachers who reported experience in teaching statistics, various features were analysed (Figure 1b). The characteristics of this subgroup of expert teachers were not significantly different from those of the whole group of teachers, except for the greater percentage of regular teachers among the expert ones (87%). Asked about using statistical tools, teachers mostly mentioned tables, diagrams and graphics, and percentages; fewer indicated statistical indexes, elements of probability, and frequencies. Teachers were asked in which subjects they had used these statistical instruments: on average, they used barely 2.7 out of 10 subjects, mainly maths (68%), geography (55%), sciences (53%) and history (32%). Statistical procedures were used to analyse data and formulate hypotheses, to start children off on new methods of interpreting data, to develop a rational mind, to work out logic and probability exercises, and applications to maths. The aims of using statistical instruments differed according to disciplinary contexts. In maths, they were used for exercises in calculations, logic and probability, and in history and geography to develop a rational mind and to start children off on new methods of interpreting data. Table 1 shows the level of association between subjects and topics, analysed by *Pearson's standardised residuals*, i.e.,

differences between observed and expected values divided by an estimate of their standard deviations, normally distributed with mean=0, and standard deviation=1.

Table 1. Subjects and topics: Pearson's standardised residuals

	Arithmetical applications	Logic/ probability exercises	Formulation of hypotheses	Development of rational thinking	Interpretation of data	*Multiple responses*
History	-1,5	-1.1	0.5	0.8	1.1	*216*
Geography	-1,6	1.0	0.7	0.5	1.2	*340*
Mathematics	2.2 (**)	1.5	1.0	-0.9	-1.3	*479*
Sciences	0.3	0.2	0.1	0.0	-0.5	*369*
Multiple responses	*228*	*261*	*323*	*285*	*307*	*1404*

(**) Sig.< 0.01

Teachers did not think that their text-books contained sufficient information about data analysis and forecasting of uncertain events (only 17% considered them sufficient), so that teaching materials were mostly taken from other sources: supplementary exercise-books (73%), alternative books (71%), and teaching manuals (71%). In the mid-1990s, Italian researchers had obtained the same results (Batic & Rigatti Luchini, 2003): the teachers in that study were experts in the mathematical field, but considered their text-books really poor or barely adequate on topics such as statistics and probability. In spite of all these difficulties, the respondents agreed that, when using statistical tools in teaching, children appeared to be more interested and that the use of these tools helped learning, not only for mathematical-scientific-technological subjects (97%) but also for historical-geographical ones (86%). Respondents were also given a set of self-anchored scaling items (from 1-minimum to 6-maximum), for self-evaluation of expertise in teaching statistics. For every proposed item (except "frequency"), having experience of how to use modalities of data analysis or how to forecast uncertain events was closely associated with higher levels in teachers' self-evaluations (Table 2).

Table 2. Self-evaluation of expertise in statistics: means and test of equality of means by experience with children: Factor Analysis Results *(Principal Component Method of SPSS 17.0)*

	With experience	**Without experience**	***Sig.* of Δ**	**Factor loadings***	
				F_1	F_2
Representing problems with tables and graphs	4.8	4.0	*.000*	.798	-.134
Creating tables and graphs to represent relationships and data	4.9	4.2	*.000*	.787	-.203
Using the Cartesian plan to locate points	4.6	4,1	*.001*	.741	-.140
Using percentages to describe daily situations	4.6	4.1	*.002*	.767	-.173
Using the concept of mean	4.4	4.0	*.005*	.780	-.327
Using graduated scales in meaningful contexts	4.2	3.8	*.012*	.759	-.164
Using the concept of frequency	4.0	3.8	*.081*	.755	-.267
Recognising and describing regularity	4.6	4.2	*.001*	.775	.077
Using diagrams to represent information	4.4	3.9	*.000*	.762	.346
Establishing the degree of probability between two events	4.3	4.0	*.029*	.740	.467
Formulating judgements and making decisions	4.6	4.2	*.012*	.662	.627

* Correlation coefficients between variables (rows) and factors (columns); squared factor loading is percent of variance in that indicator variable explained by the factor.

Factor analysis of the set of items showed two main latent dimensions: the first–positively related to all items–explained 57% of total variance; the second–positively related only to those items expressing knowledge in the probabilistic-inferential area–explained another 10%. Teachers' awareness of limits in their qualifications may be explained by a lack of training, both basic (only one-third had faced these subjects during their training) and in-service training (only 20% had taken refresher courses).

Examination of variables connected with teaching experience of statistics in class involved the use of a binary logistic regression model, in which the dependent variable (gaining experience or not) was explained by a set of predictors: some categorical (type of teacher, teaching area, higher educational qualifications, refresher courses); others continuous (years of teaching, opinion of

statistical resources in text-books, self-evaluation of expertise in teaching statistics and probability concepts (F1), and extent of preparation in teaching probability and how to use it with students (F2)

Table 3. Results of Binary Logistic Regression Model (*Block entry method of SPSS 17.0*)
Dependent variable: experience of teaching statistics to children *(1=yes / 0=no)*

Variables in the equation	**B**	***E.S.***	**Wald**	**df**	***Sig.***	**Exp(B)**
Type of teacher *(1=regular; 0=other)*	1.309	*.414*	9.998	1	*.002*	3.703
Text-book evaluation	1.112	*.373*	8.882	1	*.003*	3.041
Years of teaching	.812	*.242*	11.257	1	*.001*	2.253
Factor scores (F1)	.448	*.166*	7.302	1	*.007*	1.566
Refresher courses (*1=yes; 0= no*)	.780	*.503*	2.408	1	*.121*	2.182
Teaching area (*1=math-scient.-technological;0=other*)	.475	*.359*	1.750	1	*.186*	1.609
Teaching area *(1=historical-geographical; 0=other*)	.374	*.348*	1.156	1	*.282*	1.453
Factor scores (F2)	.177	*.158*	1.251	1	*.263*	1.194
Qualifications *(1=academic degree; 0=other*)	.332	*.518*	.410	1	*.522*	1.393
Constant	-5.019	*.973*	26.603	1	*.000*	0.007

Reference category = 0; R-square of Nagelkerke = 0.435; Overall percentage correct = 78.6%

Table 3 shows regression coefficients and their significance level. Being regular teachers with longer experience showed very remarkable effects on the probability of gaining experience with students (for regular teachers, it was 3.7 times more probable having experience than the others, as exp(B) shows (last column). In addition, text-books containing descriptions of statistical tools for teaching, and a good level of self-evaluation of qualifications in order to be capable of training students on these topics produced the same effects. Although it did not reach statistical significance level, having had in-service training appeared to be important. Some elements of statistics have only recently been introduced in Italian primary-school teachers' training curriculum, explaining the importance of these variables: teachers' competence here was mainly achieved by teaching experience and refresher courses.

CONCLUSIONS

For primary-school teachers, teaching the concepts of probability and statistics is not only significantly related to the self-evaluation of specific expertise, but also to some teachers' characteristics (type and years of teaching), and text-book evaluation. Most teachers thought it would be an interesting training opportunity in both the mathematics curriculum and in history and geography, but awareness of gaps in their preparation led them to express the need for refresher courses, regardless of teaching experience. In discussing the survey results, the students who were involved stated that only specific initial training of teachers, provided together with revision of text-books, will be able to produce large-scale changes in statistical literacy levels in new generations. Starting from the evidence presented here, our research aims at more in-depth *ad hoc* examination of the two issues which emerged as the most important: text-book contents and in-service training.

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