TRAINING TEACHERS TO TEACH STATISTICS: WHAT CAN WE LEARN FROM RESEARCH?

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TITRE

La formation des professeurs à l'enseignement de la statistique : que peut-on apprendre de la recherche ?

ABSTRACT

Although statistics is taught extensively at university level and is today part of the mathematics curricula for primary and secondary school level in many countries, the specific training to teach statistics is far from being an universal component of pre-service or professional development courses for statistics teachers. In this paper we reflect on the specificity of statistics; we analyse the contents needed in the training of teachers to teach statistics and summarise current research related to this topic. We conclude with some reflections about the need of collaboration between statisticians and mathematics educators to prepare school teachers to teach statistics.

Keywords: *teaching statistics, teacher education, professional knowledge to teach statistics.*

RÉSUMÉ

Bien que la statistique soit considérablement enseignée au niveau universitaire et fasse aujourd'hui partie des programmes de mathématiques dans les écoles primaires et secondaires de nombreux pays, la formation spécifique à l'enseignement de la statistique est loin d'être une composante générale des cours de formation initiale ou professionnelle des professeurs concernés. Dans cet article, nous développons une réflexion sur la spécificité de la statistique ; nous analysons les contenus nécessaires pour la formation des professeurs de statistique et nous donnons un aperçu sur les recherches actuelles à ce sujet. Nous concluons avec quelques réflexions sur la nécessaire collaboration entre statisticiens et formateurs en mathématiques pour préparer les professeurs des établissements scolaires à l'enseignement de la statistique.

Mots-clés : *enseignement de la statistique, formation des professeurs, connaissances professionnelles pour enseigner la statistique.*

1 Introduction

The teaching of statistics in secondary and high school has a long tradition in countries like France, Spain or the United Kingdom; however, because statistics is becoming increasingly important in modern society, the relevance of developing statistical thinking in students across all levels of education has grown. As a result of this, an increasing amount of statistical contents is being included in the school curriculum in many countries and the teaching of statistics and probability has been redesigned (see, for example, Parzysz, 2003). In countries like Australia, Brazil, South Africa, Spain, the United Arab Emirates or the United States of America, the new curricula include statistics since the first year of primary school level (6 years-old children). No doubt these changes are due to the influence from the

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International Statistical Institute (ISI), that started to pay more attention to teaching statistics in schools in the mid seventies, where the socio-economic conditions in developed countries, frequent use of quantitative information in newspapers and more widespread use of personal computers led to increasing demands of statistics education for the general citizen. The International Conferences on Teaching Statistics (ICOTS) were started in 1982 by the ISI to bring together statistics teachers at all levels, disciplines and countries and have continued every four years. These conferences were complemented with a series of Round Table Conferences focused on specific themes, the most recent of which was organised in collaboration with the International Commission on Mathematical Instruction (ICMI) and was transformed in the Joint ICMI/IASE Study on Teaching Statistics in School Mathematics. Challenges for Teaching and Teacher Education (Batanero *et al.*, 2008).

Although the specificity of statistics is widely accepted, statistics is not as an independent topic in the school curriculum, but is taught as a part of mathematics. Consequently we attend demands for a better preparation of primary, secondary and high school mathematics teachers, who are responsible to teach statistics at these levels. Although interest in the education and professional development of mathematics teachers has increased in the past 20 years, and there is now a body of research results on this issue, current literature seems to indicate that we have not come as far, in the specific case of statistics. This is evident in conferences (e.g., the ICMI Study 15), journals (e.g., Journal of Mathematics Teacher Education), surveys, and books that hardly take into account the particular case of statistics. The Joint ICMI/IASE Study was intended to address this omission by promoting research specifically focused on the education and professional development of teachers to teach statistics.

In this chapter we outline some specific issues and challenges regarding the education of teachers to teach statistics in schools, summarise the scarce research related to this topic and suggest possible activities that can contribute to the education of teachers. We pay particular attention to the specificity of teaching statistics as compared to teaching other topics in the school mathematics curriculum.

2 Teaching statistics at the school level

The reasons for including statistics teaching in schools have been repeatedly highlighted over the past 20 years (e.g., Holmes, 1980; Hawkins *et al.*, 1991; Franklin *et al.*, 2005; Girard, 2005): usefulness of statistics and probability for daily life, its instrumental role in other disciplines, the need for a basic stochastic knowledge in many professions, and the important role of statistics in developing critical reasoning. In spite of this relevance, there are still important challenges in the teaching of statistics that we summarise below.

2.1 Statistical reasoning and literacy

Changes in what is expected in the teaching of statistics do not just concern the amount but also the quality of the content. Until recently, statistics in the school curriculum was reduced to tasks in which learners were given small organised data sets and were asked to produce specific graphs, compute simple statistics (e.g., the mean or median) or answer simple direct questions. This formula-based approach to statistics resulted in students who were ill prepared for tertiary level statistics and adults who were statistically illiterate.

The current recommendations even for primary school levels suggest a data-orientated teaching of statistics where students are expected to design investigations, formulate research questions, collect data using observations, surveys, and experiments, describe and compare data sets, propose and justify conclusions and predictions that are based on data (e.g., NCTM, 2000). Learners are expected to deal with data in significant contexts and should take a critical stance on the analysis and interpretation of data, and especially the abuse, of data and statistics. The importance of developing statistical thinking and not just statistical knowledge in the students is being emphasized in many curricula that focus on developing statistical reasoning, which is essential to modern society and complement reasoning in other areas of mathematics (Gattuso, 2006; Scheaffer, 2006).

Moreover, to be statistically knowledgeable it is essential for today's citizens to be critical regarding the available information, to understand how the information is generated, as well as to be able to make personal or social decisions. Consequently, we find statistics literacy as a part of the political agenda of many countries. For example, each process component in the GAISE reports (Franklin *et al.*, 2005) contains a form of expectation that requires students to go beyond the process of "doing" statistics and typically expect students to describe or evaluate the process. Mathematical literacy, conceived as an individual's capacity to identify and understand the role that mathematics plays in society, to make well-founded judgements and to use mathematics in effective ways is also a relevant piece of international skill assessment projects, such as the Programme for International Student Assessment (OECD, 2006).

In spite of these curricular recommendations, the current teaching of statistics in schools is frequently reduced or forgotten and, at best, taught in a formal way with few examples of real applications. It often consists of only doing computations or proving mathematical theorems with scarce opportunity to design experiments, analyse data or connect statistics with the general process of inquiry. Consequently, students finish secondary school with little understanding of basic principles underlying data analysis, which explains many of the problems they encounter in the use of statistics in their everyday and professional lives or in statistics courses at the university level.

2.2 The interplay between statistics and probability

Statistics and probability are linked in school mathematics in many countries and within mathematics theory and practice but there is no consensus on the role of probability in the school curricula or in which conception of probability (classical, frequentist, subjective, axiomatic) should be included. Some curricula (e.g., in France) require implementing an experimental approach to statistics through simulations in order to prepare students to understand the law of large numbers and to grasp the interaction between the notions of relative frequency and the frequentist conception of probability. However some wording of the law of large numbers raises an epistemological obstacle because it apparently includes both a real and a theoretical object (frequency and probability) in the same formula (Girard, 2001). It is important that teachers perceive this obstacle and be careful when using this approach to probability in their teaching

Probability is also a privileged field to study mathematical modelling, because it is easy to find many everyday applications of probability that are significant for the students. Moreover, some curricula (e.g., the curriculum introduced in 2000-2002 in France) require implementing an experimental approach to statistics and probability through simulations, where some

characteristics of a mathematical model are present (Girard et Henry, 2005). But while the probability theory taught in a finite context is very simple, its abstract model part is not direct, and could require a long period of learning (Chaput *et al.*, 2008). Finally the school curriculum is forgetting the subjective point of view of probability, while many everyday applications of probability require this view, which is today widely used in the applications of statistics (Carranza and Kuzniak, 2008).

3 Teachers' attitudes and knowledge

Changing the teaching of statistics in schools will depend on the extent to which we can convince teachers that statistics is one of the most useful themes for their students. We should pay attention to teachers' statistical conceptions and beliefs since mathematics teachers' thinking is the key factor in any movement towards changing mathematics teaching and determines both the students' knowledge and the students' beliefs concerning mathematics. A better preparation of these teachers, who frequently lack specific preparation in statistics education, is also required.

3.1 Teachers' attitudes and beliefs

Teacher training in statistics is generally focused on improving the cognitive aspects of instruction with relatively little attention paid to attitudes, feelings, beliefs or motivations. However, such factors can influence the learning of statistics, or the extent to which teachers will apply what they have learned inside and outside the classroom (Gal and Ginsburg, 1994). Studies such as those by Estrada *et al.* (2005) and Lancaster (2007) coincide that teachers acknowledge the practical importance of statistics, are willing to learn more and spend more time teaching statistics. At the same time teachers feel their students experience greater difficulties in statistics classes than in other mathematical topics and they consider themselves not well prepared to help their students face these difficulties. Even if teachers have been trained for mathematics teaching, they need more qualifications to teach statistics since they have difficulties in solving statistical questions and explaining statistical concepts to students (Arnold, 2008).

Moreover, when comparing in-service and prospective primary school teachers, Estrada *et al.* (2005) found that attitudes seemed to get worse with the actual practice of teaching. While in-service teachers were more critical of the use of statistics in the media, prospective teachers found statistics to be more useful for everyday life, gave it more value for the education of citizens, assumed that they would include statistics in their teaching, and found it easier to understand as well as more interesting than in-service teachers did. This study also showed that senior teachers had a greater tendency to suppress statistics when possible and found statistics more difficult than younger teachers. Participants' perception of the difficulty of statistics was unrelated to their statistical knowledge, although attitude and its components in general tended to improve with increased knowledge.

Teachers also have subjective theories comprising instructional contents and instructional goals linked with these contents. Thus, the implemented curricula for similar statistical content might differ considerably with regard to the teachers' objectives or beliefs depending on static versus a dynamic view of mathematics and orientation towards formal mathematics versus mathematical applications (Eichler, 2007).

Certain types of knowledge – including an understanding of how students learn specific statistical concepts – are difficult to be acquired in pre-service teacher programs. Continuing professional development has a necessary role separate from that of the preservice teacher program (Lancaster, 2007) especially for primary school teachers. Lancaster's preliminary study suggests that improving pre-service teacher attitudes toward statistics contributes to assuring that teachers will be interested in taking other courses of professional development in statistics.

3.2 Teachers' statistical knowledge

Teachers' mathematics knowledge plays a significant role in the quality of their teaching since many activities of teachers, such as "figuring out what students know; choosing and managing representations of mathematical ideas; selecting and modifying textbooks; deciding among alternative courses of action" involve mathematical reasoning and thinking (Ball *et al.*, 2001, p. 453). Consequently, teachers' beliefs, pedagogical content knowledge and instructional decisions are dependent on teachers' statistical knowledge. Below we describe different research that show that many teachers, particularly primary school teachers, unconsciously harbour a variety of probabilistic and statistical difficulties and errors that might be shared with students.

As regards interpreting graphs, pre-service primary school teachers in Espinel's (2007) research lacked the experience to interpret graphs, made errors involving symmetry, outliers and cumulative frequencies. They struggled with mean and median and thought mainly in terms of qualitative variables, thereby confusing histograms with bar graphs. They incorrectly identified the relevant variable and failed to interpret the data distribution as a whole, focusing instead on specific aspects, such as the average or an outlier.

Estrada *et al.* (2005) found a worrying percentage in the sample of pre-service teachers that did not take into account outliers when computing averages, confused correlation with causality, did not relate the mean to the total, were insensitive to sample bias or believed that estimation was not possible because of random fluctuation in sampling.

The importance of the role of variation in statistics has been documented by a variety of researchers and is considered by Wild and Pfannkuch (1999) as the heart of their model of statistical thinking. However, in Silva and Coutinho's (2008) research the teachers' predominant reasoning about variation was verbal, with scarce understanding of standard deviation. This limited verbal reasoning about variation did not allow these teachers to teach their students the meaning of measures such as standard deviation, restricting them to the teaching of algorithms. None of the teachers integrated process reasoning, which would relate the understanding of mean, deviations from the mean, the interval of k standard deviations from the mean and estimation of frequency in this interval.

Canada and Ciancetta (2007) compared the pre-service teachers and middle school students reasoning about distributions as they consider graphs of two data sets having identical means but different spreads. While subjects in both groups reasoned about the task using average and variation, relatively more pre-service teachers combined both aspects to constitute an emerging form of distributional reasoning in their responses. However, about 35% of the pre-service teachers initially agreed with the hypothetical argument that there was "no real difference".

Most teachers have little or no prior experience with using statistical investigation to conduct probability experiments or simulations. Thus, they may have difficulty implementing an experimental approach to teaching probability or teaching through statistical investigation (Stohl, 2005). In an experiment organised by the author, although the participant teachers engaged students in statistical investigations through probability experiments, they often missed opportunities for deepening students' reasoning. In particular, these missed opportunities occurred during the steps of analysing and interpretation in a modelling activity. The teachers' approaches to teach the frequentist approach to probability was unsuccessful, because they almost exclusively asked their students to work with only small samples sizes. Few of them used big samples or pooled the data from the different students, so that these students could not perceived the progressive convergence. They did not examine the distributions or the variability across the different samples and therefore these teachers failed to address the heart of the frequentist approach to probability.

3.3 Teachers' professional knowledge to teach statistics

3.3.1 Models of teacher professional knowledge

In addition to being proficient in mathematics, Shulman (1987) described other types of knowledge needed by teachers to be competent in the modern classroom: general pedagogical knowledge; curriculum knowledge; pedagogical content knowledge (PCK); knowledge of learners and their characteristics; knowledge of education contexts; and knowledge of education ends, purposes, and values. Shulman conceptualised pedagogical content knowledge as a special mixture of content and pedagogy that is specific for a topic and that teachers develop as a consequence of professional practice. Shulman's ideas have been expanded and transformed over time and different models have been developed. In particular we will consider the model by Ball *et al.* (2005), who developed the notion of "mathematical knowledge for teaching" (MKT) in which they distinguished four main categories of knowledge:

- Common content knowledge (CCK), or the mathematical knowledge shared by most educated adults, that includes basic skills and broad general knowledge of the subject.
- Specialized content knowledge (SCK), as a particular way in which teachers master the subject matter that supports their activity in planning and handling classes and in assessing students' knowledge, strategies, and difficulties.
- Knowledge of content and students (KCS), or the amalgamated knowledge that teachers posses about how students learn content. This includes knowledge about common student conceptions and misconceptions, about what mathematics students find interesting or challenging, and about what students are likely to do with specific mathematics tasks.
- Knowledge of content and teaching (KCT), or mathematical knowledge of the design of instruction, including how to choose examples and representations, and how to guide student discussions toward accurate mathematical ideas. This includes knowledge about instructional sequencing of particular content, about useful examples for highlighting salient mathematical issues, and about advantages and disadvantages of representations used to teach a specific content idea

Although the above models are useful for the case of statistics some researchers try to develop specific models for the professional knowledge needed to teach statistics. Burguess (2006) started from the components in teachers' knowledge described by Ball *et al.* (2005) and crossed these categories with the essential types of statistical reasoning defined by Wild and Pfannkuch (1999): a) Recognition of the need for data; b) transnumeration, a special type of reasoning that consists of changing data representation to come to a better understanding of the data; c) being able to measure, model and control variation, that is omnipresent in statistics; d) reasoning with statistical models; and e) being able to integrate the statistical model and the context. The observation of two teachers when teaching statistics through investigations showed that most aspects of the teacher knowledge in relation to the resulting framework were needed and used within teaching. For example, one of the teachers was aware of the difficulty that students would have by trying to sort the data by too many variables and this indicated that the teacher used the intersection of knowledge of content and students and transnumeration.

Lee and Hollebrands (2008) developed a framework to describe the professional knowledge needed by teachers when they teach statistics and probability with technology tools. Following Niess (2005), they considered four components in this knowledge: a) conception of what it means to teach a particular subject integrating technology in the learning process; 2) knowledge of instructional strategies and representations for teaching particular topics with technology; 3) knowledge of students' understandings, thinking, and learning with technology; and 4) knowledge of curriculum and curriculum materials that integrate technology with learning and puts a focus on teachers' statistical thinking.

3.3.2 Assessing teacher professional knowledge

In addition to defining models for teacher's professional knowledge, several authors tried to evaluate this knowledge. Watson *et al.* (2008) prepared a questionnaire, where PCK items were based on student survey items used in earlier studies so that data were available about students' actual responses. Some items were based on media articles in the Australian context, asked teachers to predict a range of responses their students might produce if presented with a question, and then to explain how they might use the question in their classrooms, including how they might intervene to address inappropriate responses. The second set of items asked teachers to react and classify actual student responses to two questions, where the responses showed different levels of understanding of the topic.

Rasch analysis was used to obtain a measure of teacher ability in relation to professional knowledge to teach statistics and three different levels of teacher ability were identified. Teachers in the lower level were only partially successful on items that requested them to suggest students' responses and then to indicate how they would address these responses in the classroom. They demonstrated little success on items that asked them to react to actual student answers to questions. Teachers in the middle level were able to suggest both correct and incorrect responses and to find the error and make other suggestions for the item. However they were only able to suggest single generic ideas for using the students' responses to develop ideas for the classroom. In the higher level teachers showed a relatively high likelihood to focus on the statistical content involved in the responses to the problems and suggested both correct and incorrect responses to the items.

Specific research assessing the pedagogical content knowledge required for teaching and the way teachers use their statistical knowledge when teaching statistics has shown that this

knowledge is often weak. In González and Pinto's (2008) qualitative research pre-service secondary school mathematics teachers had a scant knowledge of graphical representation, no training in matters related to the curriculum and the processes of learning and teaching; specifically they knew nothing about stem and leaf graphs. They did not perceive the different cognitive levels associated with graphs (Friel *et al.*, 2001) or the various components and processes linked to their interpretation (Monteiro and Ainley, 2006). When asked to classify textbooks' graphs they focused only on the procedimental aspect of graphs and the teaching, according to their conception, should focus on the construction of graphs, the analysis of concepts and the application of algorithms and formulae. They knew nothing about the process of learning statistical graphs and the difficulties that students have around this topic.

PCK is critical for teachers at all educational levels, but it is particularly critical at the primary (elementary) school level, where teachers' preparation for teaching statistics might be limited. Although many of these teachers could perform routine instruction – such as teaching children to produce graphs and compute measures of central tendency – it is important that they also are competent to develop statistical literacy in their students, and this requires the teacher to have the capacity to critically examine and reason about real-world data. It is important that teachers are able to (a) recognize what concepts can be addressed through a particular data set, and (b) implement effective learning in the classroom with the data. However, Chick and Pierce's (2008) research shows that some teachers lack competence to plan a lesson; they do not recognise the statistical concepts that could be developed from a particular data set or resource and miss the opportunities that are inherent in a task. Their lesson plans mostly focused either on students having the experience of collecting their own data or on rules and details that would not be presented in a connected way.

4 Challenges in the initial training and ongoing professional development of teachers

4.1 Current situation in the training of teachers

Different authors coincide that we need to train statistics teachers adequately so that they are able to prepare learners to be statistically literate citizens. Even when many prospective secondary teachers have a major in mathematics, they usually study only theoretical (mathematical) statistics in their training. Few mathematicians receive specific training in applied statistics, designing sample collections or experiments, analysing data from real applications or using statistical software. The situation is even more challenging for primary teachers, few of whom have had suitable training in either theoretical or applied statistics, and traditional introductory statistics courses will not provide them with the didactical knowledge they need (Batanero *et al.*, 2004; Stohl, 2005; Franklin and Mewborn, 2006).

Teachers also need some training in the professional knowledge needed to teach statistics, where general principles that are valid for geometry, algebra or other areas of mathematics cannot always be applied (Batanero *et al.*, 2004). For example, in arithmetic or geometry an elementary operation can be reversed and this reversibility can be represented with concrete materials. This is very important for young children, who are still very linked to concrete situations in their mathematical thinking. When joining a group of two apples with another group of three apples, a child always obtains the same result (5 apples); if separating the second set from the total he/she always returns to the original set; no matter how many times

this operation is repeated. These experiences are very important to help children to progressively acquire the mathematical structure behind them. In the case of random experiments we obtain different results each time the experiment is carried out and the experiment cannot be reversed.

Research in statistics education shows that textbooks and curriculum documents prepared for primary and secondary teachers might not offer enough support. Sometimes they present too narrow a view of concepts (for example, only the classical approach to probability or inference is shown); applications are at other times restricted to games of chance or are not based on analysis of real data; finally in some of them the definitions of concepts are incorrect or incomplete (Cardeñoso *et al.*, 2005). There are also exceptional examples and experiences of courses specifically directed to train teachers to teach statistics in different countries some of them based on theoretical models of how this training should be (e.g., Batanero *et al.*, 2004; Garfield and Everson, 2009). Evaluation of the success of such courses is in general based on small samples or subjective data; but anyway they provide examples and ideas for other teachers' educators.

4.2 Activities to train teachers

Another recurring idea in the literature of training teachers is the need to use meaningful activities in the training of teachers since new knowledge (even statistical knowledge) is not automatically gained by teachers through their participation in professional development courses (Arnold, 2008).

One fundamental learning experience that teachers should have to develop their statistical thinking is working with statistical investigations or projects in order to develop sufficient statistical thinking abilities, deep understanding of disciplinary content, and the ability to copying with ambiguity and uncertainty. Some experiences of new approaches in the training of teachers to teach statistics include:

- *Promoting collaborative work* among pre-service teachers. During that training it is essential to improve professional practice because it is through the exchange of ideas and materials among teachers who have common problems and needs that new ideas emerge for the introduction of new activities, new practices or new competencies (Arnold, 2008).
- *Teachers' collective analysis* and discussion of the students' responses, strategies, difficulties and misconceptions when solving statistical problems or projects. This can reveal that teachers lack specific knowledge in some parts of statistics, for example the different approaches to probability and its epistemological problems. Groth (2007) suggests that teachers of statistics must deal with two layers of uncertainty in their daily work. The first layer relates to disciplinary knowledge. Uncertainty is also ubiquitous in teaching because of the unique and dynamic interactions between teacher, students, and subject matter in any given classroom. Therefore, teachers must understand and navigate the uncertainty inherent to both statistics and the classroom simultaneously in order to function effectively. Online case discussion among a group of prospective secondary mathematics teachers in Groth's research where they offered and debated conjectures about general pedagogy, statistical content, and content-specific pedagogy showed that cases can help catalyse online conversations in which prospective teachers challenge one another's claims and interpretations.

- *Project work.* New curriculum and methodology guidelines suggest that having teachers involved in research projects can change how mathematics is experienced in *the* classroom, especially in connection to statistics. Inquiry is a well accepted (but not always implemented) process in other school subjects, like science and social studies, but it is rarely used in a mathematics classroom (where statistics is usually taught). Moreover when time available for teaching is scarce a formative cycle when teachers are first given a statistical project to work with and then carry out a didactical analysis of the project can help to simultaneously increase the teachers' statistical and pedagogical knowledge. At the same time provides the teacher educator with information regarding the future teachers' previous knowledge and learning (Godino *et al.*, 2008). A related activity is asking the teachers to *plan a lesson to teach students* some aspects of statistics and analysing later the lesson produced.
- *Working with technology.* Lee and Hollerbrad (2008) used technology both as amplifiers and reorganisers to engage teachers in tasks that simultaneously developed their understanding of statistical ideas with technology and to provide teachers with first hand experience about how technology tools can be useful in fostering statistical thinking. We can also capitalize on the ability of some software as a tool-builder to gain conceptual understanding of statistical ideas. Technology helped teachers in Sánchez and García's (2008) experience to overcome their limitations in understanding the complex relationships between randomness, structure and variation. Integration of computer tools was critical in developing an instructional sequence for middle school teachers that would tie together the loosely related topics that typically characterize school statistics curricula and help them develop an understanding of distribution.

5 The need for collaboration

The preparation of mathematics teachers has historically been the exclusive responsibility of mathematicians and mathematics educators. Only until recently we do find some countries where statisticians are starting to play a major role in teacher preparation. In the United States of America the GAISE project was written to provide guidance to all involved with teacher preparation (Franklin *et al.*, 2005). Mathematics and statistics departments have also collaborated at national and local level in organising workshops to train the teachers in many other countries.

Succeeding in training the teachers to teach statistics is a problem that does not just concern mathematicians or mathematics educators. On the one hand, statistical offices in charge of producing statistics for a variety of applications in social, industrial, political, scientific or everyday life are increasingly concerned about the *statistical illiteracy of citizens.* These citizens are often unable to correctly interpret simple statistical information presented in the press, Internet and other media, and they are not always willing to cooperate in providing sound data needed to produce these statistics, for example the census. As a consequence there is an increasing involvement of statistical offices and associations in producing materials and organising actions that help increase statistical literacy, that is, the ability to understand and critically evaluate statistical results that permeate our daily lives- coupled with the ability to appreciate the contribution that statistical thinking can make in public and private, professional and personal decisions (Gal, 2002). The Census at school project and the associate professional development workshops provided by Canada's National

Statistical Agency, Statistics Canada as well by other statistical agencies or statistics education centres in other countries helped teachers develop statistical knowledge and teaching competencies (Hall, 2008).

The first step given by Statistics South Africa to improve the statistical level of South African teachers was getting teachers to attend the Sixth International Conference on Teaching Statistics (ICOTS 6). The launching of a teacher training campaign by the National Statistical Office in South Africa in July 2006, has resulted in a national network of statistics workshops being planned for teachers, a significant step towards solving the dilemma outlined above (North and Ottaviani, 2006). The launching of a new journal to promote the teaching of statistics by the French Statistical Society is another example of collaboration.

The interest of mathematics and statistics educators towards the Joint ICMI/IASE Study conference held in Monterrey (Batanero *et al.*, 2008) was shown in the number of papers sent from different countries and from people with different backgrounds. In spite of long discussions of the differences and similarities between teaching statistics and teaching mathematics the success of the conference showed that the time was ripe for collaboration between mathematicians and statisticians to help solving the problems of teaching statistics at school level and the training of teachers.

Despite the acknowledged fact that statistics is distinct and different from other areas of mathematics and the implied need to provide mathematics teachers with a special preparation to teach statistics, mathematics and statistics also have very much in common and there are many synergy effects between mathematics and statistics education. It is then possible to connect the statistical and mathematical preparation of teachers when time for training teachers is scarce and there is no possibility to offer them a separate course in statistics education. Conversely, the field of statistics provides ample opportunities to teach important concepts of applied mathematics and modelling as shown by Gattuso (2006). In fact, an activity-based statistics course may meet all the major demands that concern modern mathematics instruction such as preparing students to represent and analyse real situations, solve problems, make decisions using mathematical reasoning, communicate their thinking and make connections.

In summary, preparing teachers to teach statistics is an important research area and improving the education of teachers is a condition to improve statistics education at school level.

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