INTERNATIONAL COOPERATION IN STATISTICS EDUCATION IN LATIN AMERICA: THE CHILEAN EXPERIENCE

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In Latin America the field of statistics education is still at an early stage, with initial progress being made mostly by the action of particular individuals. To sustain the achievements and to obtain higher goals, cooperative work has proven to be essential and this has been the responsibility of statistics departments and national statistical associations. Globalisation offers new opportunities to promote the cause of statistical education at all levels. This paper reviews the situation in Chile, providing a brief description of some projects, with an emphasis on the role played by international cooperation. Future goals for statistical education in Chile, which are likely to be shared by other countries in the region, are mentioned and some general recommendations are given. These are virtually unattainable without appealing to the cooperation of international statistical associations or that of large national ones.

INTRODUCTION

Statistics education has a wide spectrum involving formal education programs (K-12, undergraduate, graduate), but also addressing the needs of the general public, the government and the continuous training of statisticians and other professionals. This paper is mainly concerned with levels K-12, but will briefly touch on some of the other topics. As is the case with other fields, globalisation has a great potential for improving statistical education, particularly in view of the explosive appearance of internet resources dealing with this subject. It comes as no surprise that a major source of information is the IASE web page, the International Statistical Literacy Project (ILSP, 2005) giving resources that are useful for the development of statistical literacy at all levels. The American Statistical Association also provides useful advice on many aspects of statistics education. Of great relevance are the Guidelines for Assessment and Instruction in Statistics Education (GAISE) reports on K-12 education and introductory statistics college courses (American Statistical Association, 2005). Other national statistical associations, as well as statistics education journals, provide useful teaching materials for those involved in the teaching of statistics at all levels. There is therefore an abundance of international information available, which is expected to increase dramatically in the coming years, and a great challenge is to ensure that it has an effect in teaching practices. There is an obvious unbalance between the countries generating the information, with a low percentage corresponding to developing ones. In the case of Latin America, there is a language barrier since there is not so much material generally available in Spanish.

This article starts with a brief review of the historical development of statistics in Chile, including graduate, undergraduate, and K-12 programs, as well as the role of the Chilean Statistical Society, commenting about the role of international cooperation. It then goes on to discuss some projects undertaken in Chile and finishes by making some recommendations.

STATISTICAL EDUCATION IN CHILE

Formal education programs in statistics are relatively recent in Latin America; a good description may be found in Morettin *et al*. (1985). The first undergraduate program was created in 1948 at Universidad del Litoral, in Rosario, Argentina in 1948. The first Chilean centers providing statistical training appeared in 1953, both receiving internationally funding: the Interamerican Center for the Teaching of Economics and Financial Statistics and the Interamerican Biostatistics Center (for information on the history of biostatistics in Chile see Marshall, 1993). But it is the creation in 1962 of the Interamerican Center for the Teaching of Statistics (CIENES), headquartered in Chile, by the Organization of American States that had a large effect on the development of statistics in Latin America and the Caribbean Region. Most influential was its Master's in Mathematical Statistics, with 394 graduates between 1963 and 1985, 43% of them being Chilean nationals. The international recognition of the CIENES

curriculum facilitated the admission of many of its graduates in doctoral programs abroad, which in turn helped in developing further international links. CIENES is probably indirectly responsible for the relatively large number of undergraduate programs, which is a distinctive feature of statistics in Chile. Technical degrees (3-4 years) appeared in the mid sixties, while professional careers (4-5 years) started in the seventies. A 5 year program incorporating some training in engineering and administration was created at U. de Santiago in 1994, under the name of Statistical Engineering, and this example has been later followed by 4 other universities. There are currently six Master's programs, the largest ones being Biostatistics at Universidad de Chile (created in 1983 with initial support of the Panamerican Health Organization) and Statistics at Pontificia Universidad Católica de Chile (hereafter PUC), created in 1987. Since 1998 this university also offers the only doctoral program in statistics in Chile, and its creation was greatly helped by many leading statisticians from the USA and Europe.

THE CHILEAN STATISTICAL SOCIETY (SOCHE)

Formed in 1977, it was one of the first statistical associations in Latin America, even though the field was quite underdeveloped at that time. The two main factors behind its creation were the large number of Chilean graduates from CIENES and the visit to Chile of a delegation of the American Statistical Association (ASA) in 1976, which convinced some Chilean statisticians of the need of such a society. The main activity of SOCHE has been the consistent realization of yearly national statistical meetings (32 to date). Since 1990 some of them are held jointly with the Argentinean Statistical Society every two or three years, either in Chile or Argentina. These CLATSE meetings have sometimes counted with the participation of the sister societies of Uruguay and Paraguay. This interaction has been especially helpful in the area of statistics education. Following the example of ASA, SOCHE created some sections, a recent one being that of Statistical Education, for which this ICOTS meeting will surely provide an important impetus. The Journal of the Chilean Statistical Society was one of the first of its kind in Latin America and counts with an international editorial board. SOCHE has organized sessions, short courses, and conferences on the teaching of statistics, particularly at its national meetings. The visits of Martha Aliaga and Carmen Batanero deserve special mention.

INTERNATIONAL COOPERATION AND RESEARCH

In many countries international collaboration in statistics takes place initially at the research and postgraduate level (see e.g., Demétrio, 2003 for the Brazilian experience). Apart from its Master's program, CIENES had a joint venture with PUC with the creation in 1982 of the Winter Schools in Probability and Statistics, which took place until 1994, These schools contributed to strengthening the study of probability and statistics, both in Chile and in Latin America, creating long lasting ties between probabilists and statisticians both within the region and with academic centres in the USA and Europe. These ties have indirectly helped in the organization of international meetings and in the participation of foreign scholars in national ones. As a result, undergraduates have obtained a better appreciation of statistical careers and there has been an increasing interest in following graduate studies. After 1994 funding for international exchanges has come mainly from the Chilean National Council for Science and Technology (Conicyt), the NSF, the French government, and UMALCA.

STATISTICS AT THE SCHOOL

Probability and statistics were introduced in the school curriculum in 1997, a process that was essentially controlled by mathematicians and mathematics teachers. SOCHE was asked to comment on this curricular innovation and its recommendations (see del Pino *et al*., 1996) were mainly based on American introductory textbooks for college statistics, and to some extent with general ideas expressed by Martha Aliaga, who visited Chile on several occasions. Unfortunately, the recommendations were only partially followed and the curriculum is far from satisfactory. A positive aspect is that about one third of the curriculum in level 12 is devoted to statistics, but most of it covers descriptive statistics, only taught previously at level 8. In between (levels 10 and 11) there are only some disconnected pieces of probability, with little emphasis on the context and with its applications to statistics. A major problem, in which Chile is certainly not alone, is that

mathematics teachers have little or no training in statistics. As a consequence, they tend to stress the computational aspects, with little technological support, or they even skip teaching the subject altogether, despite its mandatory character. The new mathematics curriculum has put the teaching of statistics at high school on the spot and part of the Chilean statistical community has correctly perceived that this is an important problem to be tackled. Most efforts have been oriented to training teachers, but there are some experiences on teaching the students directly. So far there have been no internationally supported projects in this area, beyond partial support for the visits of a few foreign experts, who have participated in local meetings and other activities.

SOME CHILEAN EXPERIENCES IN STATISTICAL EDUCATION

Some activities are described here, with the main focus on those developed by faculty of the Department of Statistics at PUC (R.Aravena, G. del Pino, P. Iglesias, and W. Palma).

Teleduc (PUC): PUC has an open TV channel, which for several years offered a variety of short courses, structured in a program called TELEDUC, that were broadcasted on Saturday mornings. In association with the Department of Statistics, the course *"Statistics: Understanding a world with randomness"* was devised. It consisted of 12 weekly 30 minutes TV sessions and an accompanying textbook (del Pino *et al.*, 1989), counting with highly professional director, actors and script writer. The script had humoristic undertone and was carefully checked for possible distortions of the statistical contents. The course started with the basic concepts of population and sample, as well as descriptive summaries, but it also covered more complex topics like hypothesis testing, quality control and experimental design. The main character was a private investigator who finds by accident a monograph on statistical research methods and gets obsessed with it, making the common mistakes of a first time student. A surprising aspect was that the series was very popular with small children. A sample video was shown in one the Brazilian Symposium of Probability and Statistics (SINAPE) obtaining a positive reception and some interest in making use of this material in teaching. Unfortunately, TELEDUC did not promote this product in other Spanish speaking countries, and tried to recover the high production costs by charging a large sum for the rights to exhibit the course videos. Thus they have only been used locally to supplement introductory undergraduate courses in statistics. A positive lesson is the synergy between the teaching of statistics and acting, which has been retaken in a different form by P. Iglesias (see below); a negative one is that a lot effort was wasted for lack of a proper distribution strategy. It is hoped that the communication tools available today and the more open attitude to sharing resources avoids that a similar situation arises again.

Explora (PUC): Explora is a Science and Technology Outreach Program created by Conicyt in 1995, which finances small projects aimed at school students. The project *¨Randomness, Science and Society¨* was carried out in 1999, with a sequel in the following year. It involved 20 schools and 200 level 11 students, with their mathematics teachers acting as facilitators. The direct contact with the students was quite limited and had the form of a small workshop with three modules: Statistics and Media (4 hours); Exploratory Analysis (8 hours); and Probability (10 hours). Groups of students (1 o 2 per school) presented statistics proposals which were discussed in plenary sessions with all students and received suggestions from their peers and from the project team. They then had a time to develop the projects and there was a final presentation and an awards ceremony. The total execution time of the project was about five months. Probability proved to be the most difficult for the students and the 2000 version reduced combinatory to a minimum, placing more emphasis on physical and computational simulation. A Probability Fair was organized, where students designed games with probabilistic contents. Their diversity and creativity were impressive.

PENTA (PUC): An educational program for gifted children from a low socioeconomic background was created in 2001. Students choose freely among the courses offered by different university departments, with a class size of about 20 students. All the courses are structured in 15 three hours sessions. Three statistics courses have been designed and they have been given by faculty members with the help of graduate students and a high school mathematics teacher:

1. *Randomness: Games and sampling.* The course contents include random choice, samples, physical and computational simulation, variability, sampling variability, descriptive statistics, statistical regularity, independence, equiprobability, games, and use of Excel. This course was originally developed for level 7, but with some adaptations has also been applied to levels 10-11.
2. *Obtaining, exploring and squeezing data:* The basic ideas are similar to those used in the second module of the Explora project, but with much more time for direct contact at the expense of no possibility of extra work at home. This course was originally developed for levels 10-11, but with some adaptations has also been applied to level 7.
3. *Statistics and theatre:* This course was jointly developed by a statistician (Pilar Iglesias) and a primary school mathematics teacher and actress (Lina Wistuba), for level 7 students, who create collective plays addressing statistical concepts: exploratory data analysis, probability, and statistical inference. The idea has been replicated with statistics majors at PUC and one of the plays has been already presented by a professional company. More details can be found in http://pliz.isoft.cl/.

PPF: This was a program of the Ministry of Education (Mineduc) for training teachers in different areas, which was in effect for many years. It was biased towards didactic and pedagogic aspects, at the expense of the substantive area expertise. In the case of universities, the courses were mainly controlled by the Schools of Education, which were not qualified to teach the subject matter. Lectures were concentrated on one week in January, after which the teachers had to develop a teaching project. In 2002 the mathematics courses concentrated for the first time in statistics, since this was a new topic in the curriculum. A major conflict emerged involving the schools of educations, mathematics departments, statistics departments and the corresponding national societies. Under the leadership of SOCHE many statistics courses were organized along Chile and prove to be generally successful. At PUC lectures were based on a chapter of a mathematics textbook written for Mineduc to be distributed to all public schools (unfortunately the book was not finally printed). Computing laboratories were also used and two high school teachers took care of the pedagogic aspects.

EPES (PUC): The success of the PPF program organized by PUC led Mineduc to invite the Department of Statistics to participate in a more ambitious project later on the same year. It involved a teacher training program organized in 7 sessions of 4 hours long that took place on Saturdays and were spread over 5 months. The student-teachers work there own proposals and a video was produced to show some of the lectures the teachers taught at their own schools. The lectures concentrated in probability, given the weakness the teachers felt they have in this topic. However, the most important product was a short statistics book designed for high school teachers that was freely distributed by Mineduc to all public schools. The textbook presents the concepts through press articles, experimentation, cartoons and links to real life situations.

Web Page Instruction: Most work has been devoted to introductory undergraduate statistics courses, though some of this material may also be used by high school students. Jorge Galbiati personal page contains a wealth of interesting material and it also has links to other projects developed by other faculty members of Universidad Católica de Valparaíso, e.g., Galbiati (2005) and Pascual *et al.* (2005). For electronic lecture notes for probability and statistics see also http://www.estadistica.cl/~agora/. Gloria Icaza has coordinated a nationally funded project to incorporate web-based instruction into service statistics courses, which has counted with the collaboration of Martha Aliaga and Carmen Acuña (see Icaza *et al.*, 2006). There is not much experience in distance learning for teaching education in statistics, one exception being the work of Claudio Silva (then at U. de Santiago), who designed a unit on information processing for decision making (see Montero and Silva, 2000) within a more general project on interactive distance training for teachers with technological support.

SOME RECOMMENDATIONS FOR INTERNATIONAL COOPERATION

1. National statistical associations play an active role in furthering the cause of statistics education. The ISI or other national associations with a long tradition may provide help in creating them and facilitate the development of sections in statistics education. These could in turn establish links with IASE.

2. Many universities have groups that have activities in statistics education and, although they may interact to some extent, there is natural degree of competition between them since they may apply to the same sources for funding projects. Foreign or international organizations may act as a catalyser for producing joint projects involving several universities. There may be a leading university, but in some cases it could be feasible that the formal leadership lies in the national statistical association.

3. Statistics education must not be disassociated from the applications of statistics and its place in a modern society. Political authorities need to be made aware of the general importance of statistics before they give a high priority to statistics education, and international cooperation may help in this in two ways. First, it would be especially welcome to receive well documented experiences, where governmental agencies express their positive perceptions about statistics. A national statistical association may serve as natural medium to convey this external information to the government. This interaction with the governments is not straightforward and the experiences of other such associations would be valuable. The International Statistical Institute could provide assistance in systematizing this information.

4. An advantage of our discipline is the substantial agreement on the education strategies at different levels. Furthermore, there appears to be full consensus on things that should be avoided, but are often done but are often done. In many countries, as is the case in Chile, the teaching of statistics at K-12 is under the control of mathematicians and educators, which are often not well prepared in this area. When the national statistical community is small, it is hard for it to have enough leverage to make things change on its own international collaboration is essential. This may take place through exchange visits or through the creation of standards enjoying a wide agreement. The American Statistical Association Guidelines for Assessment and Instruction in Statistics Education (GAISE) Project is a good example and it would be useful if most of them could be endorsed both by IASE and other strong national statistical associations, perhaps preparing a new document. This would be indeed a powerful tool for local statistical associations and Statistics Departments in their discussions about education at the school level and the curriculum of service courses.

5. To teach statistics effectively requires a proper understanding of its purpose and a clear demonstration of its usefulness. The worldwide web has improved the access to real data and case studies, but it is still not so simple for to instructors to translate this access into their concrete teaching practices. The StatLib site at www.stat.cmu.edu, founded in 1989 by Mike Meyer, is mainly focused at the university level and a similar site at the school level would be very useful. To some extent the ILSP site covers these needs, but there is little material written in languages other than English. To improve on this situation there are two simple initiatives that could be implemented quickly: (a) To fund proposals for the translations of selected English resources into other languages, with adaptations to make them adequate to different social and cultural environments (this might require permission from the authors) (b) To encourage those that develop materials in other language to put them on the web and link them to ILSP and other statistical education sites. A more ambitious project is the development of well structured sites which contain data sets in context, ideally with indications or examples about its use in teaching, but this would require a major funding.

6. Statistics education initiatives demand a lot of effort and there is much excitement when they are being carried out. Looking back on some of the experiences described in this paper, there is often less attention put into the dissemination of the products obtained and/or of the lessons learned while executing particular projects. The existent statistics education sites, meetings

and journals provide good possibilities to change this situation and so they should be made widely known to all statisticians.

7. Although in the past local projects may have been developed without much reference to the international experience, the globalization process makes this inappropriate. Although independent thought is good for creativity, there is a great danger of making avoidable mistakes. Here again the key issue is to make it widely known all the resources available today.

8. The urgent need of statistical training for large numbers of teachers makes distance learning an attractive option. There is not however enough experience on this and international support is required here. It must be bared in mind that what works in a developed country may not work in developing ones and that large differences may be expected within this second group. There seems to be however some evidence for the need of some direct contact for obtaining good results. There are some possibilities that the governments invest resources in such a project and the help of international associations would be welcome. The preparation of teaching material for distance learning is a very demanding enterprise, which has been so far been undertaken by small teams, but really requires international support.

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