THE TRAINING OF PRIMARY SCHOOL TEACHERS IN STOCHASTICS AND IN STOCHASTIC EDUCATION IN EUROPE

Antonio Estepa
Universidad de Jaén, Spain
aestepa@ujaen.es

In this paper we analyse the available resources, potential difficulties and principles in the training of primary school teachers in stochastics and stochastic education and then present a proposal for a syllabus to train primary school teachers in this field that takes into account the restrictions and aims of the European Higher Education Area.

INTRODUCTION

In the last decades, statistics and probability contents have increased in the primary school curriculum in most countries. Consequently, it is necessary to introduce stochastics (statistics, probability and combinatorics) and stochastic education into the curriculum for the training of primary school teachers. On June 19, 1999, the European Ministers in charge of Higher Education of 29 European countries signed the "Bologna Declaration" (www.bologna-berlin2003.de). This document is the origin of the Bologna process, in which universities, students, the European Commission and other organizations participate. At present, 46 European countries have signed the Bologna process that aims to create a European Higher Education Area (EHEA) by 2010, in which students can choose from a wide and transparent range of high quality courses and benefit from smooth recognition procedures of studies across Europe. The EHEA does not aim to homogenize the European Higher Education but to make it more compatible and comparable. The EHEA: a) is a framework that paves the way for undergraduate, graduate and lecturer exchange schemes; b) will organize university education at three levels: bachelor, master and PhD degrees; c) will recognize the degrees of the European countries that form part of this process; and d) will facilitate European cooperation and will guarantee quality. The EHEA presents a challenge to all European universities as they must adapt their educational curricula to the EHEA, including training syllabuses, teaching methodology, learning activities, and assessment. In this paper, we aim to discuss the resources available and pedagogical criteria used to elaborate a training syllabus on stochastics and stochastic education for prospective primary school teachers that can be adapted to the demands of the EHEA.

RESOURCES

In order to elaborate a training syllabus on stochastics and stochastic education many university lecturers count on the following resources: pedagogical guidelines from the government; statistics books; educational research literature; school textbooks and professional experience.

Pedagogical guidelines from the Government

In many European countries the adaptation of Higher Education to the EHEA will be made in accordance with the pedagogical guidelines that the Government dictates to the universities. These pedagogical guidelines must contain the philosophy behind these studies and their organization, with a view to making them comparable to those of other European countries.

Statistics books (content, history and epistemology)

We have at our disposal books of statistics and probability, in which basic probabilistic and statistical concepts including their properties and applications are developed for our purposes (at an adequate level for teachers); books on the epistemology of statistics and probability, and books with contents of the history of probability and statistics, are also very useful from an educational point of view. These three types of books will help teachers extract epistemological reflections on the probabilistic and statistical concepts and the acquisition of meta-knowledge on statistics and probability, which are important components of the teacher's

 In C. Batanero, G. Burrill, C. Reading & A. Rossman (Eds.), *Joint ICMI/IASE Study: Teaching Statistics in School Mathematics. Challenges for Teaching and Teacher Education. Proceedings of the ICMI Study 18 and 2008 IASE Round Table Conference.*

"didactical knowledge" (Batanero, Godino & Roa, 2004).

Stochastic education research literature

Most problems concerning stochastic education have not yet been solved. Nevertheless, there is research on stochastic education that can be useful for elaborating a training syllabus for future teachers. Research on stochastic education includes: the learning of stochastic concepts, difficulties, errors, conceptions and misconceptions, textbooks, stochastic knowledge and reasoning, development of stochastic reasoning, teacher training, statistics and computers, assessment. Neither books nor articles on this subject are mentioned because the list would be very long (some references can be found on the IASE publications web site (www.stat.auckland.ac.nz/~iase/). Future teachers must be familiar with research results on stochastic education, since according to Nicholson and Darnton (2003, p. 4) "teachers who are not familiar with common difficulties and misconceptions may miss opportunities to help pupils confront these and achieve a deeper understanding of core concepts."

School textbooks

These are an important resource for all in-service teachers and subsequently, they should be used in teacher training as a reference to the knowledge that is taught in the primary school classroom. Therefore, future teachers must analyse sequences of teaching and learning activities in school textbooks and know the results of research on stochastic textbooks since this research (e.g., that by Estepa & Sanchez , 1998) found deficiencies and biases in these books.

Professional experience

The university lecturer, through his professional experience, agglutinates his stochastic, epistemological, pedagogical and practical knowledge to elaborate a good training syllabus on stochastics for future teachers.

"A PRIORI" DIFFICULTIES

When trying to elaborate a new curriculum, it is advisable to consider potential difficulties in its design and implementation. I will now proceed to reflect on the most likely difficulties in a course for training teachers to teach statistics.

When entering the first year of training, prospective primary school teachers have different levels of statistical and probabilistic knowledge, ranging from students who have never studied stochastics to those who have taken one or several courses. Moreover, some student teachers who have studied stochastics commit errors in elementary statistical concepts similar to those of primary school children (Stohl, 2005). In addition, an important proportion of student teachers do not like either mathematics or statistics/probability. The teacher trainers should make a rational analysis of their educational programme in order to motivate students, correct deficiencies and errors of the teacher trainees and decide the minimum knowledge that teachers should acquire, considering the research results available (Shaughnessy, 1992; 2007).

At the present time, all stochastics or stochastic education courses include some computer-based activities, but prospective teachers have different levels of computer literacy at the start of their training, varying from students who do not know how to use a computer to those with a good command of commonly used computer programmes.

Prospective teachers have their own conceptions about teaching and learning mathematics and stochastics that are difficult to change; for example, teachers tend to teach as they were taught (Eichler, 2006). Contrary to prospective primary school teachers, students beginning other university degrees of which they have little vital experience (for example, engineering, journalism, law, veterinary, medicine) have no strong preconceptions about the skills they should acquire to develop their future profession. Consequently, they acquire suitable conceptions about what an engineer, journalist, lawyer or veterinarian should do in their period of training. However, students who intend to become primary school teachers have a long vital experience about learning and teaching. Throughout their life "they have enjoyed" or "suffered" the learning and the teaching as students; therefore, they have strong-rooted conceptions about teaching and learning. In many cases, these conceptions do not correspond to those the lecturer tries to transmit to the future teacher and remain unaltered, despite being inadequate. The

changing of these conceptions about teaching and learning is an important challenge for teacher trainers since it is a difficult task (Wilson & Goldenberg, 1998).

Stochastics is only a part of the knowledge that prospective teachers have to teach in their future profession, and consequently, teachers are not going to specialise in stochastic education. Furthermore, as aforementioned, some students do not like the topic; accordingly, the stochastics and stochastic education curriculum will be designed bearing in mind that some students harbour negative attitudes to the subject.

PRINCIPLES FOR TEACHING STOCHASTIC EDUCATION TO PROSPECTIVE TEACHERS

If one considers the mathematics and stochastics curriculum for the training of primary teachers one should have a better understanding of the teaching-learning of the subject. I will now analyse some principles derived from research results (for example, Watson, 2001; Heaton, & Mikelson, 2002).

1. Consider the students' previous knowledge. Students have previous knowledge about stochastics in the sense that some students will understand elementary concepts about statistics and probability; some will know nothing about statistics and probability; some will think stochastics is a very difficult subject; and others will think that stochastics is similar to mathematics and should be taught like mathematics.
2. Modify the prospective teachers' inadequate teaching and learning conceptions. This principle is derived from the previous one. As stated previously, prospective teachers generally have teaching-learning misconceptions, especially in relation to stochastics. The way of changing these misconceptions should be pondered on by the teacher trainers when planning their teaching (Hill, Rowan & Ball, 2005)
3. Stochastics and stochastic education should serve to solve real life and educational problems. If future teachers value the usefulness of knowledge, it follows that they learn; otherwise they will feel that stochastic topics are useless, tedious and hard, and will come to the conclusion that these topics are of no interest for their students.
4. Stochastics and stochastic education concepts and procedures should be introduced as effective tools to solve problems. For example, when introducing the teaching of stochastic topics to future teachers, a relevant activity is to propose to the teachers some tasks taken from primary school textbooks in order for them to reflect on issues such as: the concepts and procedures needed, the difficulty of the task for their students, the clarity of the statements. In this way the future teacher will understand the usefulness of stochastic education for their future teaching practice from the beginning.
5. Action and social interaction facilitate learning. This principle is well known and derives from psychological research, including the findings of Piaget and Vygotsky.
6. Knowledge should be valid and adapted to the society requirements. Society demands professional training from its universities, training that provides students with enough skills to carry out their work productively according to the needs of society.

In addition to the knowledge we try to teach students, future teachers acquire another type knowledge in their daily learning practice. In this "hidden curriculum" prospective teachers usually take a leaf out of the teaching methods used by their educator. If these prospective teachers believe the practices are appropriate for their teaching, they will put these principles into practice in their professional life. Hence, the methodology we use should correspond to the educational theory behind the training of the prospective teachers.

A PROPOSAL FOR TRAINING PROSPECTIVE PRIMARY SCHOOL TEACHERS IN STOCHASTICS AND STOCHASTIC EDUCATION IN THE EHEA

In this section I present a proposal for stochastics and stochastic education in the new curricula for teacher training adapted to the European Higher Education Area and to the European Credit Transfer System (ECTS). We should bear in mind that we are training generalist teachers (teachers who will teach all the different subjects to children) not teachers

specialised in stochastic education. The complete education of the teacher is similar to a puzzle, where each subject is a piece. If prospective teachers are able to fit all the pieces so the puzzle is perfect, then the teacher training process will be excellent; otherwise, the teaching training process will have deficiencies.

In addition, we should take into account that stochastics and stochastic education is included in mathematics and the teaching of mathematics but has its own specificity; stochastic knowledge and reasoning are different from mathematical knowledge and reasoning (no determinism versus determinism). For example, a mathematical problem has only one solution; by contrast, a statistical problem has more than one possible solution (Gattuso & Pannone, 2002). The didactic consequences of these differences should be borne in mind during teacher training (Lopes, 2006).

General aims

When the training syllabus has been realized, the prospective teacher should: a) have a grasp of elementary stochastic contents; b) understand the role of stochastics in current society, the problems it can solve and the fields where it can be applied; c) understand the extension and limitations of statistical thinking; d) know the results of stochastic education research related to elementary school levels; e) know the advances in methodology for teaching stochastic concepts and procedures; and f) acquire the capacity to design teaching sequences to transmit elementary stochastic ideas.

Content

According to Shulman (1986), all teachers should acquire two types of professional knowledge: content knowledge and pedagogical content knowledge. My proposal is based on these two types of knowledge. Since many prospective teachers have little stochastic knowledge, a programme for stochastic education for them should begin from the most elementary concepts and procedures. In addition, the future teacher must acquire a positive attitude towards knowledge, school, culture, books, and work well done. Stochastic education must contribute to this.

A review of the literature on teachers' professional knowledge (e.g., Shulman, 1986; Llinares & Kraisner, 2006) suggests that the training of teachers should include knowledge of content, knowledge of teaching processes and knowledge of their students. A comprehensive knowledge of statistics is the first step in training the teachers and should be complemented with the following types of knowledge: a) epistemological reflection on the meaning of concepts to be taught that can help them to understand the role of concepts within statistics and other areas, the importance of the concept in students' learning and the students' conceptual difficulties in problem solving (Batanero, Godino & Roa, 2004); b) curricular foundations to develop teachers' capacity to analyse textbooks and curricular documents, adapt concepts to different teaching levels and students' various levels of understanding; and c) psychological foundations and results from statistics education research that will serve teachers to develop and analyse assessment tests and instruments and interpret students' responses to the same.

Teaching methodology

Methodology should be in line with the European Credit Transfer System (ECTS) and the European Higher Education Area. Consequently, it should be inspired by European projects such as the Tuning project (unideusto.org/tuning/) and adapted to the ECTS. This methodology includes the following types of activities:

- Lectures. Some sessions should be devoted to guiding students in the structure and documents of the course in order to avoid the students wasting of time in looking for course materials without aid.
- Tasks. I propose three types of individual or group tasks that should always be carried out under supervision: a) tasks in which students apply the knowledge acquired in a practical way; b) tasks in which students construct knowledge; and c) tasks given at the beginning of the course and related to professional context. For example, teacher

trainees can solve exercises from primary school textbooks or reply to questions similar to those they will need to solve when they are school teachers and planning their teaching.

- Projects. These constitute the essence of educational statistical work. Both the sharing of teamwork and the opportunity to share knowledge and experiences with other colleagues performing the same projects is important in the education of the future teacher (Makar, 2007). Although the learner's work is different from that of the professional statistician, generally speaking, the data analysis phases are similar: studying the problem, collecting and organizing data, representing the data, describing and interpreting the data, developing hypotheses and theories based on the data. Therefore, projects have a high educational value in teacher training.
- Written and oral communications. Oral and written communication will facilitate specific learning of stochastics and will provide general skills in the future teacher's education.
- Searching for bibliography. Searches should be both in university libraries and on the Internet. It is evident that different bibliographical references have different approaches to curricular subjects that enrich the education of the future teacher.
- Use of computers. The computer can be used with different aims in the training of teachers (see some examples in Watson, 1998; Peck & Gould, 2005): as a tool for statistical analysis, as a learning tool to facilitate the learning of some concepts through exploration and simulation, as a search tool to find resources located on the Internet, and to carry out at distance education. For example, at the University of Jaén (Spain) we use a Web-based learning management system (LMS), Integrated Logistics Information and Automation System (ILIAS, www.ilias.de/), to teach stochastics and stochastic education, among other topics.
- Final project. This final project should include most of the contents learned in the course. In addition, it should offer the student the possibility of applying widely his/her knowledge. To assess the statistical learning, I sometimes propose that the prospective teachers do a final project comparing some data and for this purpose I give them a data set containing personal characteristics of a group of student teachers in 1986. Prospective teachers should collect a data set with the same variables from among their classmates and compare both data sets in order to find similarities and differences between current prospective teachers and those 20 years before.
- Assessment. As required by the ECTS, assessment should comprise all the activities and tasks that the student has developed during the course, including the final project. In addition, designing and analysing a reasoned teaching proposal constitute important professional skills and should therefore be considered in prospective teachers' assessment.

CONCLUSIONS

In this paper we analysed the available resources, difficulties and principles that should be taken into account in order to elaborate a proposal to train teachers to teach stochastics. Developing such a proposal is not an easy task due to the restrictions described to which we should add legal, scientific, pedagogical and affective issues. Another remark is the scarcity of teaching materials devoted to the didactic preparation of statistics teachers as compared to materials related to teaching mathematics or teaching other topics.

Teaching methodology is the most demanding aspect of a proposal adapted to the ECTS system and will require a big effort from those in charge of training teachers. Statistics educators are now responsible for providing support to teacher educators and organising research related to training teachers to teach statistics. We hope the initiative started in the Joint ICMI/IASE Study will continue and lead to a better preparation of teachers, which in turn serves to improve statistics education.

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