A PROPOSAL FOR CHANGING EDUCATIONAL PRACTICES IN THE TEACHING OF PROBABILITY AND STATISTICS

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In this report we present a proposal to work in the classroom starting from some theoretical and conceptual elements that might be used for teachers when facing the problem of teaching the main probability and statistics concepts in the Colombian context. We first reflect on the knowledge that is offered in the country and then outline a didactic work approach from exploratory data analysis.

A GLANCE AT PROBABILITY AND STATISTICS EDUCATION IN COLOMBIA

Nowadays probability and statistics are part of mathematics curricula for primary and secondary school classes in many countries and Colombia is not an exception. Several reforms that affect the present state of probability and statistics education have been recently made in Colombia. Such innovations have brought with them changes in the content of different stochastic subjects, whose study is approached at different educational levels. It is possible to find at least three components in the changes: guidelines, curricular standards and goal-oriented assessment. As a result of these transformations we find a great variety of themes in our content , depending on the character of the curriculum and the academic program (commerce, technical academic, pedagogical, etc., at primary and secondary education; administrators, economists, social workers, health sciences, etc. at upper level).

When thinking about the knowledge to be distributed at schools we have first to talk about curricular guidelines that develop the theoretical and conceptual frame around the so called *random and statistics thinking* (Rocha, 2002) for levels one to eleven of primary and secondary education (Bonilla *et al*., 2002). Two conceptual units are found in relation to these standards for these levels:

1. Describing a data set (descriptive statistics).
2. Elements of probability (describing random events, estimating probabilities for simple and compound events, basic probability distributions).

In relation to university education, there is a tendency to distribute the study statistics teaching in two courses, usually after having taken a mathematics course and around the third or fourth semester. The content is the same as previously described, although the study is made at a higher level of complexity. Some statistical methods (hypothesis tests, linear models, variance analysis etc.) that are required for later curricular development are also frequently included within the second semester in the course. Finally, depending on the main field of study, other topics necessary for the students' conceptual development and directly related to statistical reasoning (Sampling, Psychometrics, Econometric, Statistics Education etc.) are included. Consequently, it is urgent to offer statistics teachers a better prior training as well as continuous support from University departments and research groups. In this paper we present some ideas about how to carry out the training of primary and secondary school teachers in Colombia.

PRINCIPLES FOR IMPROVING STATISTICAL EDUCATION

Several fundamental ideas that can lead the teachers, research groups and institutions actions to improve statistics education in the country have been taken from the international academic community:

1. Advancing the country's statistical literacy and enculturation, that is, advancing (a) people's ability to *interpret and critically evaluate* statistical information, data-related arguments, or stochastic phenomena, which they may encounter in diverse contexts, and (b) their ability to *discuss or communicate* their reactions to such statistical information (Gal, 2002; Batanero, 2002).
2. Taking into account the theory suggested by Batanero, Godino and Roa (2004) in developing training proposals for teachers; a) epistemological reflection on the meaning of concepts we

try to teach; b) analysis of knowledge transformations to be adapted to different educational levels; c) study of students' learning difficulties errors and obstacles and to their problem solving strategies; d) curricular analysis.
3. Results from research in Statistics Education, particularly in what concerns students' difficulties and statistical development.
4. The role of New Technologies in both the practice and the teaching of statistics.
5. Introducing inferential reasoning in middle, junior and high school levels.

CONCEPTION OF THE TEACHER UNDERLYING OUR PROPOSAL

In this section we present some theoretical elements that are currently being developed at the University Distrital Francisco José Caldas, in Bogotá, within a curricular project proposal for Basic Education with emphasis in mathematics. Our assumptions are that:

- Every teacher that survives his daily work develops a knowledge we can characterize as "*knowing to do.*" That is to, he/she possesses a practical knowledge, a *knowledge about how to do.*
- This is a complex, multirelational, systemic and reflective knowledge.
- It is a reconstructive knowledge, since before starting the teaching profession, the future teacher already has some preconceptions about what being a teacher involves, about the topic he/she teaches, and about the actions he/she should carry out in the classroom.

Azcárate (1996) additionally determines three basic aspects that teachers and future teachers have to know and reflect about if they want to confront, with some guarantees of success, statistics education: a) the conceptual field and its specific features; b) cognitive development and learning; c) peculiarities of education.

CONCEPTUAL ELEMENTS UNDERLYING OUR PROPOSED MODEL FOR STATISTICS TEACHINGS

The model is based mainly on three conceptual elements: firstly, the development of classroom projects as a didactic strategy; secondly the theory of didactic situations to design the classroom work; and thirdly, exploratory analysis on which to base the statistical work. Below we summarize these elements

Classroom Projects as a Problem Solving Method

A classroom project is mainly characterized by the development of statistical work when approaching a problem (that should be located in some social, economic, political context). Some hypotheses are set if necessary, a statistical model that allows the study of the problem is selected, information using diverse sampling techniques is compiled, the statistics of interest are computed, the results of the inferences, estimations or prognoses are analyzed and the solution is evaluated in relation to the original problem and context (Batanero and Díaz, 2004).

Function of the Teacher in this Approach to Resolution of Problems

Design of the classroom project as far as possible should be the responsibility of the teacher in the spirit of this proposal. Moreover (Document of previous accreditation, 2000) the teacher should reinforce the statements and activities that generate problematic situations, to introduce and privileged "new" representation models, to contribute to a search for contradictions and ambiguities in the reasoning's and solution proposals, to lead to construction of the usual mathematical language (UML) and foster worthwhile argumentative UML forms. He should explicitly make knowledge, reflections, and argumentations appear in the classroom, coming from some previous activities unfolded by the students on a statement proposing a situation that questions the students' previous knowledge. This way he assures that:

1. All the students have enough tools available to approach the problem, and are interested to solve it.
2. No student counts with all the tools needed to solve the question at the moment the statement is set.

3. Different points of view arise with respect to a specific statement (of course this is not a problem but one of the reasons that unfolds the activity in the classroom).
4. When institutionalization of the obtained knowledge arrives, the students should have passed through the phases of investigation, formulation, argumentation and validation, where opportunities for compression and reconstruction of the initial knowledge are multiplied.

In this sense research by Massialas and Cox (1966) display other educational functions of problem solving (Polya, 1969), such as: a) planning and preparing a suitable atmosphere, by means of challenging problems, presented and adapted to the students; b) stimulating students to organize their own investigations; c) stimulating discussions, mainly when students are losing interest.

Theory of Didactic Situations

The theory of didactic situations was proposed by Brousseau (1993 a and b) as a model for learning processes. This theoretical approach includes four different phases and the following conceptual elements: Didactic contract, Didactic transposition and Didactic situation. The way in which Didactic Situations organize the teaching of subjects included in the programs, implies a certain conception of the construction of knowledge process. The main features of these situations are: a) Students formulate personal projects; b) The activities proposed by the students are carry out to obtain a final result they have to anticipate and verify ; c) Students try to solve the problems d) Students resort to some strategies. e) Students settle down social relationships (ways of socializing their work). In synthesis we should "face students to a situation that evolves in such a way that the knowledge e want them to learn is the only effective means to control this situation."

Other Modeling Elements

Other elements related to the didactic situations theory and that also affect the educational process are didactic transposition, epistemological obstacles, heuristic and a-didactic situations.

COMPONENTS OF EXPLORATORY DATA ANALISIS

According to Figueras and Gargallo (2003) exploratory data analysis is a set of statistical techniques whose purpose is getting a basic understanding of the data and the existing relations between the analyzed variables. Batanero and Godino (2001) suggest the following main didactic components of exploratory data analysis: a) possibility of generating learning situations in topics of interest for students, b) strong support on graphical representations, c) it does not need a complex mathematical theory.

In order to properly develop exploratory data analysis we suggest the following phases:

1. Arranging the statistical information collected in such away that the use of some statistical. method technique is possible.
2. Carrying out a first graphical exploration that allows the student to approach the observed data nature and structure; data analysis using some statistics or different graphical aspects
3. After the two previous stages, diagnosing reliability and the degree of acceptability of the assumptions needed to use the statistical methods.
4. If assumptions are verified, the student would explore the degree of interrelation between variables, using statistics measures and taking into account the problem structure.
5. Making estimations or prediction from the graphical information and statistics computed.
6. Recognizing atypical data and its effect on prognoses and estimation, by using graphical information.
7. Finally the students would analyze the usefulness of the observed information, its characteristics and possible consequences.

EXPECTED RESULTS OF OUR PROPOSAL

We expect teachers that use the above model of classroom work will help students develop the so- called fundamental statistical reasoning (Wild and Pfannkuch, 1999) where

students: recognize the need for data, use transnumeration in developing a greater understanding of data when changing representations, increasingly perceive internal and external variation in data, reason with mathematical and statistical models, and integrates the statistic in the problem context.

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