ANALYZING TEACHER RESISTANCE TO TEACHING PROBABILITY IN COMPULSORY EDUCATION

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From the beginning of the nineties, the different curricular reforms in Spain have favoured the introduction of probability. However, the reality in the classroom is very different since teachers show resistance to accepting this curricular innovation. To explain this situation, the "Professional Development Teachers" research group in the University of Cadiz carried out research dealing with teachers' conceptions of probability, the sources of professional knowledge used to teach probability, and the probability content in Spanish textbooks. In this particular paper we will present results form a case study where teachers' arguments to justify their resistance to introducing probability in Compulsory Secondary Education are analyzed. A theoretical framework related to the knowledge of probability and pedagogical professional knowledge is introduced in order to interpret the teachers' reasoning and understand the evolution of teachers' intervention in the teaching and learning process.

INTRODUCTION

Since the early 1990s, several proposals have been put into effect to change the curriculum of Spanish school mathematics. Amongst these changes, we would note the introduction of probability into the curriculum of compulsory education. In response to this institutional reform, while numerous publishing houses have come up with new curricular proposals, these proposals all maintain a character of continuity with traditional pædagogical principles (Martínez Bonafé, 2002). While their textbooks present the units of probability, they lay more stress on other blocks of knowledge (arithmetic, algebra, geometry, analysis) (Serradó, 2003). Faced with the external imposition of incorporating this new body of knowledge and with the sparsity of the information presented in the textbooks, teachers have shown themselves to be fairly reticent to include probability in their teaching proposals.

Our interest was to determine and analyze the arguments that teachers give to justify the absence of any knowledge of probability in their teaching proposals. In association with this objective, we formulated two questions that guided the research to be described in this presentation.

What Reasons Do They Give For Not Introducing The "Treatment Of Chance"?
Did The Information Sources That They Use Influence This Decision?

On the basis of our experience, we thought that the teachers would present different reasons to justify their decision not to introduce probability. We considered that the introduction of probability represents a curricular and methodological innovation for the Compulsory Secondary Education teacher that could favour his or her professional development. Our research group's study "Professional Development of the Teacher" (Hum462: "DpD") is focused on the progressive construction of a corpus of meta-knowledge about "Professional Knowledge."

The process of this construction allows us to approach in a systemic, holistic, and complex manner the understanding of the dimensions and factors involved in the said knowledge. The proposal serves as a referent for the analysis of the teachers' arguments and of the elements that influence their decisions on the teaching and learning of probability.

THEORETICAL FRAMEWORK: PROFESSIONAL DEVELOPMENT

We regard professional knowledge as a system of ideas with different levels of specificity and articulation, which is subject to constant evolution and reorganization, and allows one to establish hypotheses of progression in its construction (Azcárate, 1999). The problem is approached theoretically from the perspective of three referents that characterize the professional knowledge that the teacher has to bring into play during the process of teaching and learning probability.

The first is that of *the teachers' conceptions about intervention*. From a constructivist

standpoint, these conceptions are regarded both as tools that favour the evolution of the teaching community, but also as barriers to that evolution (Porlán, Rivero, and Martín del Pozo, 1997). The analyses of the ontological and epistemological views expressed by the teachers, and of their actions during intervention, allow a hypothesis of progression to be established that delimits certain tendencies in those conceptions about the process of instruction:

- *Traditional tendency*: This promotes the presentation of a closed, hierarchized, and linear structure of knowledge that allows for only a minimal intervention of the student.
- *Innovative teaching tendencies*: These attempt to give the students a bigger part to play in their learning and actions. They promote the active participation of the student based on their carrying out a set of activities that are elaborated and sequenced from scientific standpoints.
- *Investigative-type tendencies*: These imply a conceptual change that is founded on the cognitive theory of learning. They modify both the part played by the teacher and the part acquired by the student, being associated with proposals that involve a strong participation of the students. In this sense, the axis of the methodological structure is investigation into meaningful problems that respond to the students' interests. They are a referent in the study of the processes of teaching and learning statistics and probability (Pratt, 1998, 2000; Sáenz, 1998).

The second is that of *the sources of information the teacher uses* in planning his or her intervention. The analysis of these sources of information —of when, for what, and how they are used— allows us to establish a hypothetical itinerary of progression in the use of the said sources (Serradó, 2003):

- *Initial level:* Basically, a single information source is used in planning intervention. This is the textbook, which will guide the planning of the development in the classroom.
- *Intermediate level:* A varied set of information sources is used (the students' previous ideas, the obstacles and difficulties facing the construction of the target knowledge, data from the students' environment, data from the communications media, ordinances, textbooks, computer programs, manipulative resources, etc.), which serve as a support for the teaching.
- *Reference level:* The sources of information used are highly varied. They depend on the type of problem proposed in the classroom, and are elements that form an integral part of classroom activity.

The third is *a hypothesis of progression in the knowledge of probability*. This hypothesis is based on the ideas presented by Shaughnessy (1992), Azcárate (1996), and Cardeñoso (2001), with which they attempted to construct an overall explanatory model of how individuals function when faced with situations of uncertainty. From the studies that have been carried out, we differentiated four tendencies in how teachers handle this kind of knowledge in the classroom.

- *Excluding the treatment of chance from the curriculum:* The arguments given for why this block of content is not presented are essentially that more importance is given to other blocks of content with deterministic foundations. More importance is given to the quantification of probability than to understanding the notion of probability.
- *Presenting the treatment of chance intuitively:* There appear some explanations of the meaning of chance, establishing its relationship with natural phenomena, experiments, and random events. They try to compensate the lack of a suitable conceptualization of probability with a greater emphasis on the quantification of probability based on experiment. One finds such arguments as that referring to the *contingency of the event*, put into practice by means of part-wise comparisons. Quantification is limited to presenting *Laplace's rule* and the *frequency expression*.
- *Presenting the treatment of chance as an emergent phenomenon:* Different interpretations of the conceptual notion of probability are presented, such as the *Laplacian* or the *frequentist*. They apply these notions to the quantification of probability in every type of context, on the basis of incomplete combinatory reasoning.
- *Normative treatment of chance:* Their explanations are indicative of profound reflection on the different mathematical models in the treatment of uncertainty (*Bayesian*, *classical*, or *frequentist*), of its interactions, and of the complexity of its application to different situations. These reflections point to the necessity for an axiomatic presentation of probability, and for an integrative vision based on the *theory of measurement* (Cardeñoso, 2001).

These ideas and hypotheses of progression provide us with a system of categories and

indicators that facilitate the design of research instruments and the interpretation of the data that is obtained with them.

METHODOLOGICAL DESIGN OF THE STUDY

The methodological framework of the present study is *interpretative and qualitative*, using *case studies* as its basic strategy, and with the objective of analyzing teachers' arguments about the presence of probability in teaching and learning processes. A multiple case design is used, with a sample of five subjects. The attributes or parameters defining the sample are the teachers' years of experience, their degree qualifications and specialization, the recognition of carrying out educational practices of an investigative or innovative nature, and whether or not probability is included in the classroom. Of these five subjects, we shall here only present the results corresponding to two.

Teacher A has 5 years experience. He is a mathematics graduate with a speciality in probability and statistics. He does not habitually carry out curricular innovations, and does not present probability in the classroom. *Teacher B* has 2 years experience. He is also a graduate mathematics, with a speciality in analysis. Neither does he habitually carry out curricular innovations or present probability in the classroom.

The *data gathering instruments* were an open questionnaire and a semi-structured interview. The objectives of the questionnaire were: to detect the possible external factors that might influence the teachers' decision not to present this block of content; to determine the possible difficulties that the teacher considers his students might find in learning the knowledge of probabilities; to confirm the prerequisite knowledge that the teachers believe their students should have; to determine which they believe to be the key content of these units; and to determine what methodological strategies they believe should be used in the classroom to present this unit, and to compare and contrast them with those they use for other units. The information of an exploratory nature that was gathered by the questionnaires was contrasted with a semi-structured interview given to each teacher. This allows one to inquire into the two teachers' systems of ideas and to better understand their reasoning.

The questionnaire and interview results were subjected to a qualitative analysis that allowed us to classify their content into units of information. The categories of analysis used for this purpose were: the educational or functional purpose of introducing probability; their own and their external referents of a traditional character used in selecting the content and in their conception of the process of its learning; the influence of scientific determinism on the decision process; the information sources used by the teachers; the difficulties that they foresee might arise in the teaching-learning process; the methodological strategies needed to present probability; and the motives for introducing the units. Of these categories, we shall here exclusively present the results corresponding to the influence of the traditional referents.

TRADITIONALISM-RELATED RESISTANCE

We understand by traditionalism in mathematics teaching and learning a tendency in the teacher's intervention that is characterized by a lack of reflection about what and how to teach. The teacher considers that these aspects are fixed externally by educational and mathematical tradition, as is indicated in the theoretical framework.

Notwithstanding this previous lack of reflection about what and how to teach, the two teachers of the sample were asked to reflect about and discuss how this traditional view of the meaning of mathematics conditioned their decision not to teach probability in Compulsory Secondary Education. Both teachers expressed their first conscious referent with respect to mathematics tradition in relation to their undergraduate studies.

> *Because I had the sensation, for example, when I got to the Faculty and they explained to me for the first time what probability was that all that was a totally strange world. (Teacher B.)*

His first contact with probability was in the Faculty, where he did the speciality of analysis. He considers, however, that it is necessary to learn probability in Compulsory Secondary Education because it can be transferred to real life.

> *I believe that yes it can be useful to them… because it maybe is something that indeed they see more in daily life than, for example, the polynomial unit. (Teacher B.)*

One might think that the usefulness of probability in everyday life could be a motive for presenting probability. This is not the case, however, as Teacher A indicated to us.

Right now with the students that I have I do not see it as a necessity. (Teacher A.)

The official curricula describe the need to reflect on the functional and educational purpose of learning probability. It seems that the teachers do not grant it sufficient functional purpose to incorporate it into their curricular project, and neither do they believe its teaching to be important at the educational level.

In the sense that, first the kids who go to an educational level it gives me the sensation that they are not going to need probability, statistics yes, in the 4th course I do give descriptive statistics. So probability gives me the sensation that they are not going to need it as much as other blocks. And in Bachillerato [pre-university] exactly the same, they are not going to need it, especially the first courses of Bachillerato. It gives me that sensation, I may be mistaken, but I believe really that the algebra, geometry, analysis content is more important than the topic of probability and statistics. (Teacher A.)

And this in spite of the fact that Teacher A specialized in probability as an undergraduate.

If I were to do probability in the classroom, it would be more than anything because I did that speciality in the Mathematics Faculty and I did statistics and probability because I like it. That is to say, it would be more a personal taste than a criterion of saying: well, because you have to give it, or because it is necessary to give it. (Teacher A.)

One is led to think that the resistance of the two teachers is independent of their undergraduate studies. Teacher A, with a speciality in probability, does not even consider the necessity of incorporating probability into the curriculum. Teacher B, with a speciality in analysis, does consider the possibility, but does not teach it.

So statistics, well probability as far as I know, has never been touched in my school, yes a bit of statistics… I don't know… descriptive statistics but… but little more. So clearly, if I stick to what the department is doing and to tradition, I hardly dare either to… (Teacher B.)

The same teacher describes what it means that his colleagues in the Department are very traditionalist in their proposals and procedures.

Let's say that the members of the department are very traditional and so, if you go into the department there is practically nothing but textbooks, or whatever and this year there has indeed been talk of buying something, but there is nothing, not even a calculator, there were, but what there were are already obsolete. (Teacher B.)

The teacher suggests that traditionalism is also due to the Department's teachers' lack of resources and information sources. These resources are basically reduced to textbooks. Previous results indicated that the two teachers' basic information source is the textbook. They use it fundamentally in the selection and organization of knowledge (Azcárate, Serradó and Cardeñoso, 2004). Even though the textbook is one of Teacher B's principal information sources, he shows resistance against using it in the probability unit:

So we go into another problem and it is that… the presentation of probability in most textbooks is very algebraic, very arithmetic; that is to say, nothing from the point of view of reasoning, but setting up problems so as to arrive at a solution by again using a series of techniques or rules of the game. (Teacher B.)

This simple and concise argument expresses clearly and pointedly the reality of the units of Spanish textbooks dealing with probability — in most cases, the presentation is of a traditional type (Serradó, Azcárate and Cardeñoso, 2005). Furthermore, both teachers believe that this reality also carries over to the classrooms.

The students are used to arithmetic, to working with numbers. In fact mathematics is synonymous with arithmetic, and it is also synonymous with… if you actually get into algebra, with letters, only x and y of course, then the mathematics that they demand is really that, an arithmetic mathematics. (Teacher B.)

This traditional selection of mathematics content —of an arithmetic and algebraic nature— is not the one set out in the official curriculum, which proposes a probability based on

experimenting with real situations.

> *That it is going to be more a probability of sets, a probability where it is more formal, and perhaps the probability that I am going to give is more a probability of intuition, more, that… a probability where the kid gets this and sees, intuits, but not of formalizing probability. So, perhaps this is going to be left as very volatile for what later you are going to give in Bachillerato. (Teacher A.)*

This resistance to introducing probability is based on the lack of formalization of probability content, and, in particular, on whether methodological strategies are considered that permit more participation on the part of the student. Indeed, greater student participation would favour evolution towards a more innovative educational tendency with respect to intervention.

> *I suppose that it will also depend on how you approach the topic, but at least as to what the students are used to as of now in how mathematics is presented in the classroom, for them it would be learning new rules of the game. (Teacher B.)*

This greater participation of the students would, in a certain sense, foster their experimenting with and reflecting on the knowledge of probability.

> *I believe that there are many experiences in which they would capture the concept more quickly, I believe that yes it would be rapid, there are many things that repeat, for example the subject of the life of a light-bulb… are examples that they see clearly, a bulb does not last always has a probability, a probability function… In principle, searching well for experiments, I believe that there should not be any problem. (Teacher A.)*

Teacher B, however, is not in agreement with this interpretation.

> *Because also after you ask them to interpret something and they are unable, I mean, if I ask them to apply the Laplace rule they do it, but if you formulate a question in which they have to interpret the little number that they get out, experience tells me that practically the majority don't do it. (Teacher B.)*

In Teacher A's last argument, he seems to be willing to innovate and introduce the curricular and methodological changes required in order to include probability in the curriculum. But,

> *If I were to change this scheme, it would be from exchanging opinions with other teachers, that they give me their methodology, their point of view… that I see that they give good results and then I would change… I would test first to see if they give good results and I would change it. But so as introduce one topic more or one topic less, I believe not. (Teacher A.)*

Teacher B, on the other hand, expresses greater resistance to methodological change and increased student participation; it reflects a problem in class management. Spanish teachers believe that this is one of the worst problems in Mathematics Education.

> *So… it scares you not being able to control the situation. If it already costs us life itself in a group of twenty-five students… man, that they keep quiet is absurd because if they are shouting and jumping about but they are working and learning, for me fantastic, but fear about not controlling the class, that really the days go by, the sessions go by, and nothing gets done obviously it's not you setting the pace, they have to set it. And I believe that it is this fear of wasting time, and in part the effort, the work in preparing the units which makes you not change. (Teacher B.)*

FINAL IDEAS

For Teacher A, the possibilities of innovation must come from information sources arising from contact with colleagues, favouring evolution and the introduction of slight methodological changes. No change in content is considered, because he believes that probability has insufficient educational consistency at the Compulsory Secondary Education level, and neither does he grant it any basic functional purpose for these students. His arguments in defence of this resistance are based on the traditionalism of both secondary education teachers and the textbooks. Throughout the interview, Teacher B expressed resistance in reference to the learning difficulties that the students might find with a methodology of an innovative nature. He suggests that such a methodology would facilitate advancing beyond traditional mathematics —algebra and geometry— by bringing functionality to learning. The traditionalism of the students and of

the members of the department, and the lack of information sources, represent barriers to the possibility of innovating and presenting probability.

Both teachers can be included in a traditional methodological tendency. They do not introduce probability because they think that this is not a basic learning, although textbooks and curriculum introduce these units. So they do not use sources of information that could help them to change their thinking. We can conclude that they are in a initial level of the hypotheses of progression developed in the theoretical framework.

This case study gives us deeper information about why these resistances took place and how they can be solved. In order to try to solve them teachers must have a consciously training about the teaching of probability. To improve this situation we are developing the project "Enhancing the Teaching and Learning of Early Statistical Reasoning in European Schools" (226573-CP-1-2005-1-CY-COMENIUS-C21).

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