AN ON-LINE PROFESSIONAL ENVIRONMENT TO IMPROVE THE TEACHING OF STATISTICS

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We present the foundations of a professional development program supported by the European Union (COMENIUS Project 226573-CP-1-2005, developed from December 2005 to December 2008), whose objective is to propose professional development strategies that foster the integration of the teaching and learning of statistical reasoning in European schools. The intention of the program is to promote professional development through cross-cultural collaboration between teachers of different European countries. To this end, an on-line professional learning environment has been designed. We present the referents that allow us to interpret the teachers' reasoning and to understand how their intervention in the teaching and learning processes evolves.

PRESENTATION

Our everyday reality is an environment subject to high levels of uncertainty. In this environment, the ability to analyze, interpret, and communicate information is a necessary skill to become more critical in the analysis of that reality. It is this that underlies current curricular tendencies in which concepts of statistics and probability are taking on ever more important roles (Begg & Pfannkuch, 2004; Gattuso, 2006; Lopes, 2006). Most teachers, however, have little or no prior experience with many of these topics in their own schooling and teacher preparation programs. The research literature provides clear evidence of both prospective and active teachers' poor level of comprehension of statistics and probability (Cardeñoso, 2001; Serradó et al., 2006). These teachers consequently tend to focus their instruction on technical and formal aspects but offer no adequate treatment of conceptual understanding (Watson, 2001; Meletiou, 2003; Serradó et al., 2005).

Our objective is to analyze how teachers can be aided to become capable of preparing teaching designs that will allow their pupils to acquire the basic ideas of statistics. From our perspective of researchers into teachers' professional development, we feel that every school-level change has to be preceded by change at the teacher level, and that this change is closely linked to teachers' reflection on their own field of action–the classroom (Azcárate, 2005, Cardeñoso & Serradó, 2006). This is the essence of the orientation of the professional development proposal under study.

The project presents a professional development proposal aimed at responding to some of these issues and at contributing relevant information for the improvement of teacher education in this field of mathematics. Its ultimate objective is to optimize the teaching and learning of statistical reasoning at the compulsory education level. The proposal is configured as part of a professional learning environment ("The 'EarlyStatistics' Course"), which is built on certain common principles and has been implemented in three European countries (Cyprus, Greece, and Spain). Its development is based on collaborative processes supported by technological resources and subjected to a rigorous process of research to allow assessment of its suitability and effectiveness.

OBJECTIVES AND FOUNDATIONS OF THE PROFESSIONAL DEVELOPMENT PROGRAM

Experts in education and professional organizations (GAISE, 2005) agree on the need to provide environments of active learning that encourage pupils, through inquiry and discussion, to construct relevant and meaningful knowledge of mathematical concepts. In spite of the numerous calls for the adoption of new, more learner-centric practices, these find little response amongst teachers. Indeed, research points to the persistence in teachers of traditional, teacher-centric practices (Gattuso, 2006).

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In order to foster more effective professional development that is capable of generating real changes in classroom practice, it is necessary to adopt new pedagogical models in the teacher education processes themselves. Most of these processes are organized around studying stochastic knowledge itself and its peculiarities. They take no notice, however, of the complex cognitive and educational aspects involved in its learning or, above all, its teaching. For these processes to be successful, they will have to allow teachers to take an active part in communities of cooperative learning, in which they can exchange their ideas and experiences with other teachers when they are in the process of designing and implementing new strategies in their classrooms (Azcárate, 1999; Barab et al., 2002).

Since pupils build their knowledge actively by solving problems and interacting with their classmates, we should use this same approach with the teachers, especially if we want them to later use a constructivist and social approach in their own teaching. The social construction of knowledge embedded in dialogue creates new opportunities for self-reflection, growth, and intrinsic motivation (Jaworski, 2001). This is the line that forms our basic referent for our designs and actions as teacher educators (and as members of the research team). It is underpinned by three main ideas: (i) the importance of the interaction between the teachers, the teacher educators, and the technical resources used; (ii) the importance of collaboration and reflection for effective professional development; and (iii) the potential of inquiry and exploration as a process of construction of knowledge (Ponte, 2001). We have designed an on-line learning environment that allows teachers to be the principal agents of their own professional development, at the centre of their learning, thereby fostering their independence and self-directed learning (Kayler & Weller, 2007).

In our view, coherence between how the content is be taught in the compulsory education classroom and the strategies used during the professional development process is fundamental to facilitating the teachers' construction of the keys and tools that will allow them to explain and organize their future intervention (Azcárate & Serradó, 2005). This does not mean that we want them to merely clone the strategies brought into play in the professional development program but that the strategies they use in their classrooms should respond to the same principles. Thus, if present statistics teaching tends to be data oriented, there should be an emphasis on the role of the pupils themselves who are to learn in and from the context, endowing the statistical information and knowledge with meaning. In the same sense, the teachers too have to learn in and from their context, i.e., their professional practice, and the problems that arise in that context.

The professional profile that we are aiming for is compatibile with the idea of the teacher-researcher. Reflection is therefore one of the professional skills on which most interest has to be centred, since we consider it to be of especial relevance for a teacher's professional practice (Azcárate & Serradó, 2005). In this sense, the characteristic of our theoretical referent is that we consider mathematics teachers' professional development to be inextricably linked to reflection on their educational practice and in processes of curricular research on statistics teaching in particular (Azcárate, 1999). In this sense, the organization of the program has to take into account questions related to the elaboration of these three basic referents. In constructing their professional practical knowledge with respect to statistics, through reflection they must integrate three basic referents that define what they have to put into practice during the teaching process: (a) epistemological–the conceptual and pedagogical comprehension and mastery of the content; (b) cognitive–understanding statistics learning and how to foster it; and (c) practical–the development of the skills and strategies of classroom intervention.

THE DESIGN OF THE PROFESSIONAL LEARNING ENVIRONMENT

To respond to the different principles indicated above, a complex methodological structure was drawn up to aid teachers to specify and explain their own ideas on the teaching and learning of the statistics content and to establish meaningful and relevant connections between the new concepts. The proposal is organized into three parts determined by the different practical problems that arise in each of them and that reflect an evolutionary treatment of professional know-how.

The axis of the professional learning environment is the design, development, and

evaluation of an intervention proposal for each teacher's classroom, configured in the form of a scenario. The debate about and resolution of the problems and questions that arise or are put forward during the process are linked to the three referents indicated in the previous section. Thus, the methodological structure is divided into three parts, differentiated by the nature of the activities and of the questions to be debated.

First Part: Educational Content

This part is centred on the study and inquiry into statistical knowledge itself, its learning, and its teaching. The stress is on enriching the teachers' professionalized knowledge of statistics. Through the resolution of situations and reflection supported by experimentation, the use of simulations and visualizations, and the available technological means, the teachers go deeper into their understanding of the main concepts of probability and statistics. Analyzing a set of pre-prepared scenarios, they reflect on the nature of statistical knowledge, the development of statistical reasoning in children, the commonest erroneous concepts among pupils of different educational levels, the impact of technology on learning, classroom management, the use of educational software, and how to organize the teaching so as to involve their pupils in the learning of this knowledge.

Second Part: Planning and Experimentation

The activities will be targeted at the design and development of a scenario for their classrooms. From the ideas debated previously, each teacher will select a problem situation, and design around it a teaching proposal for their classroom, which they will then put into practice. In this part of the development of the program, the teachers will each implement their particular intervention proposal in their classrooms. With the support of the team of instructors, they will personalize and extend the materials provided to make them applicable to their own classroom situation. In this case, the questions raised for debate and the exchange of ideas among the teachers in the forums will be analytical in nature and oriented to making the teacher aware of decision making.

Third part: Evaluation

Finally, a third part of the process will be aimed at encouraging the evaluation of what has been learned and the result of the experimentation in the classroom. This is a phase in which the process is reflected on and assessed.

The methodological strategies applied during the development include the study of open inquiries, use of real data, simulations, visualizations, and collaboration and reflection on the teachers' own ideas and experiences and those of the others, as basic instruments to promote professional development. With the use of these strategies, we provide a learning environment for the teacher that invites their professional development and at the same time serves as a referent for their own teaching practice.

In this methodological design, the role of the team of instructors is fundamental. They pose the questions and problem situations that allow exploration of the teachers' conceptions about the different aspects to be dealt with. They interact to enable these conceptions to evolve on the basis of inquiry, by raising questions for discussion, facilitating scripts of analysis, and encouraging interaction. The strategies proposed in the development of a multilingual e-learning platform (www.earlystatistics.net) facilitate interaction and communication among the teachers involved in the three countries. In this methodological structure, the activities that the teacher has to do during the process and in each cycle are of great importance because they form the basis for debate. The following section presents an example of the kind of activities proposed. The principal aim of the selection is related to the first part of the course in reflecting on the meaning of mathematics and statistics problem solving.

EXAMPLE OF ACTIVITIES AND THEIR ANALYSIS

The title of the activity is "Investigating and Enhancing Children's Reasoning About Problem Posing and Solving." In this activity, the teachers will participate in a whole-class e-forum to discuss–on the basis of some suggested readings and their own thoughts–the problem-

solving process in statistics and ways in which the mathematics curriculum can help promote statistics problem solving. The activity consists of two tasks. The following is a transcription of these tasks as the teachers can read them in the EarlyStatistics module course and a brief analysis of some of the interventions:

TASK 1: The meaning of problem posing and solving

1. First we propose that you read carefully the following documents: Nitko, A. J. and Lane, S. (1990) and Lesh, R., Amit, M. and Schorr, R. Y. (1997), in order to reflect on some of the questions raised.
   - What does it mean to "use statistics in problem solving"?
   - Which processes of problem solving are described in the literature?
2. Participate in the discussion forum by posting a response addressing the following:
   - What kinds of student activities involve working with statistics problem solving?
   - Nitko's article suggests that solving problems is not enough to construct statistical knowledge. Can you reflect on why you think that this statement is true or false? In which sense?
   - In which sense do you think that the problems must be based on real scenarios in order for the learning to be adequately contextualized?
   - What is the process of problem solving and construction of knowledge that is described in Lesh's article?

TASK 2: Curricular analysis

1. Real the Guidelines for Assessment and Instruction in Statistics Education (GAISE, 2005) Report, which provides a curriculum framework for Pre-K-12 (Pre-kindergarten to high school) statistics instruction. Also review your national mathematics curriculum.
2. Participate in the discussion forum by posting a response addressing the following:
   - How is problem solving presented in your national mathematics curriculum?
   - How much emphasis is placed on problem solving in the statistics strand of your national mathematics curriculum?
   - Which is the proposal regarding the promotion of statistics problem solving within the mathematics curriculum put forward by the GAISE report?

The analysis of the content of the interventions in the e-forum related to the tasks that had been presented previously showed that the teachers reflected on different levels of approaching the subject. Firstly, they reflected on the significance of problem solving in statistics.

> That indeed when problems are set in real life situations, situations that are part of our students' lives, then we can be assured that our students will better understand the problem and would be surely motivated to solve it! Regarding Nitko's article, I agree that problem solving is not enough to construct statistical knowledge.

Their reflection on the importance of the construction of knowledge leads them to analyze in what contexts this takes place.

> I think that only with solving problems it's a bit difficult to construct statistical knowledge. But could pupils construct their statistical knowledge only with the other domains? I think that it would be just as difficult as the other way round. However I like Nitko's domains division, although I would give more importance to solving problems.

The teachers believe that the presentation in contexts or scenarios not only fosters learning but also the development of certain mathematical skills.

> Real scenarios do help the students get seriously involved, realize more easily how to induce reasoning and abstract thinking, feel a kind of personal responsibility so as to

> provide a serious as well as justified answer to the problem posed, which certainly leads them to exploit more options possible in solving the problem posed. It is essential though that the problem is stated clearly, challenging the interests of the students involved.

Although one might think that these are theoretical reflections, the teachers' main concern is how to make use of them in the classroom.

> I took students aged from 7 years. In my case, as stated in the article, it is important to find a good setting because they are beginning to work with statistics and apply them in their daily lives: using two simple variables and beginning to analyze the data they collect, making charts, seeing other variables including those of their peers, drawing conclusions among all of them as a group.

As in other studies of teacher development (Azcárate et al., 2006), the problems the teachers find in the lack of motivation of their pupils stand out.

> What can we do to minimize the feeling of boredom of our students? I find it difficult to answer this question sometimes when I am preparing the next lesson. It is not easy to find something interesting for every lesson – and once you do, the students demand another one next time! The GAISE report is a good theoretical way of teaching but what if you have to implement it in everyday practice? Shouldn't you use some sessions for "just theory"? And how would your students react at this loss of "happy time" in the classroom?

CONCLUSIONS

During the course of the performance of the program in the different contexts, the team of trainer and researcher-teachers developed in parallel a process of assessment research. This is based on documents and descriptions elaborated by the teachers themselves, a critical analysis of their individual work, their work and reflections as a group, and their exchange of ideas and views about how to improve their practice of statistics teaching and raise the level of competence achieved by their pupils. The findings of the present study will be used towards improving and modifying this pilot course for its integration into the COMENIUS Training DataBase.

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