

STOCHASTICS IN THE PROFESSIONAL DEVELOPMENT OF PRIMARY SCHOOL TEACHERS

Celi Aparecida Espasandin Lopes
Universidade Estadual de Campinas, Brazil

Teachers widen their professional development and their pedagogical practice by writing and publishing about their experiences in preparing and developing activities in statistics and probability. In this study data were collected and then analysed by triangulation. The role of reflection in teacher development, the relation with the curriculum and the relation with the collaborative work emerged. The results promote the development of the teacher's professional role to create the teaching and learning process in terms of children's cognitive development. Teachers work within many constraints but still create very sensible solutions for practical situations and are active innovators of the curriculum

1 INTRODUCTION

This research was carried out in Brazil and is based on teachers' epistemological reflection and critical reflexive practice with regard to stochastic ideas in basic education. It was developed with a group of teachers working with children 4 - 6 years of age.

Work with probability and statistics has been introduced in the mathematical curriculum all over the world. A central focus on probability and statistics has emerged in mathematical syllabi around the world, because learning from these two areas is very important for students to be more critical in the analysis of reality.

Stochastic education helps students solve more complex problems apart from enriching the reflexive process. Society nowadays is based on knowledge that demands skills for selecting and analysing situations and for verifying chances and decision-making. Children have the opportunity to exercise their intuition in different contexts throughout their life and thus observe probability values in more or less probable situations.

Based on these facts the teaching of statistics and probability in elementary school has been a main research focus recently in many countries. This research focus takes into account that the information world is changing fast and probability knowledge is of great importance in making decisions and foreseeing situations.

Statistics and probability are part of the mathematics curriculum in elementary schools and kindergartens. These topics allow students to develop the ability to collect, organize, interpret and compare data in order to obtain conclusions, which is the basis of any scientific attitude and performance. The role of the school is to provide statistics and probability education to students, even in kindergarten, that will help them in the exercise of their citizenship because they need to know how to analyse and critically relate the data by questioning its veracity.

Statistics and probability in the classroom could be explored through mathematization, where to mathematize means to formulate, systematize and make judgments about ways of understanding reality. Hence this activity must take place as an integrated part of the learning process (Skovsmove, 1994). To make this process effective it is necessary for both the children and the teacher to be involved in its control.

2 CHILDREN'S EDUCATION AND THE TEACHING OF STOCHASTIC

Children's education has become, in the past years, an area of concern and interest for educators and researchers, who want to produce educational work. Currently in Brazil the age of children at this level of schooling is zero to six.

Moura (1995) considers that the purpose of educating children under the age of six is not accelerating, but broadening their development. This author considers this is necessary to improve the child's possibilities, its interests and tendencies, having in mind that the child has not only to be prepared for future life, but also for the present one.

In this scenario, mathematics has been justified as necessary for children so that they can build and create knowledge and develop imagination and creativity, as well as, using it for social necessities in their lives. Different abilities and mathematical competencies are being required more often from people.

Fischbein (1975) comments that the teaching of stochastics should start at children's elementary education, and that this is not only possible but also necessary because not being trained in this subject leads people to develop wrong intuitions.

The aim of this research is to show that the development of statistical and probabilistic thinking, which should be inserted into the school context, may produce important contributions for the children's growth. Doing experiments that involve guessing and estimating, as well as collecting, representing and analysing contextually relevant data can broaden their universe of competencies and increase their creative potential.

The Brazilian National Curriculum Reference for Children's Education (1998), considers that children should have much experience with the mathematical universe, which enables them to discover things, relate others, start organizing logical thinking and finding their space. The following criteria are highlighted: identifying the notions that children have; selecting the contents; and, making them useful in classroom activities.

Although these topics are presently included in these documents, it is surprising that there is no reference to work that develops stochastic thinking. While developing a Master's research, the author studied some international mathematics curricula, in which recommendations and orientations about the teaching of statistics and probability are included for all levels starting from children's elementary education (Lopes, 1998).

In order to develop stochastic thinking students need to formulate research questions, solve problems and carry out probability experiments. These activities help students to perform critical analysis and make decisions while facing the uncertainty of everyday life. It is necessary to view school mathematics as a way of providing more investigation, reflection and creativity, breaking away from the determinism that predominates the mathematics curricula. Therefore, if this emphasis is given beginning with children's elementary education it can help the growth of a student to think more comprehensively about different issues and accordingly establishes strategies and techniques to solve everyday problems.

Shaughnessy (1992) criticizes the delay in changing towards stochastic teaching and mentions Garfield (1988) who presented four aspects for the effective teaching of stochastic teaching: the role of probability and statistics in the curriculum; the link between research and instruction; the preparation of mathematics teachers; and the way in which teaching is currently being assessed.

Even when stochastics is entering the schools in an extended way, the number of people doing research in this area is still quite small. Research has shown the importance of adopting statistics education in our schools, because people will use it greatly in different areas of knowledge, notwithstanding if they are being taught or not.

3 TEACHERS' DEVELOPMENT AND STATISTICS IN EDUCATION

In analysing the ways to educate students to think stochastically, we should rethink the teachers' role in the teaching and learning process.

Many researchers such as Godino and Batanero and Flores (1998) point to difficulties in training of teachers in stochastics as one of the main difficulties to overcome. They suggest that stochastics education cannot be reduced to developing conceptual structures and tools for problem solving; we also have to guide students to build ways of thinking and a solid system of correct intuitions.

In addition to these issues, which are related to specific content, the participation of the teachers as Mathematics educators should also be focused on the consciousness of the political action involved in their pedagogical practice. According to Kincheloe (1997), teachers legitimise certain beliefs through their actions and not others.

The teaching of stochastics contributes to this fact, since, the teacher should provide a pedagogical space, where processes are given more value than facts, ideas are preferred to techniques, and a great diversity of problems involving other areas are proposed to help students develop positive attitudes towards this topic. It is also important that students face different problems concerning their real world and that they are given possibilities to choose their own strategies to solve them.

The authors believe it is necessary that teachers encourage students to socialize their solutions, to accept criticism, to appreciate their own work as well as other students' work. In this context, the work with probability and statistics is very

valuable, taking into account its natural problems, which helps enrich the reflexive process.

The work with stochastics in the classroom should promote discussions and reflections to solve problem-situations proposed by the students or by the teacher. The teacher should always encourage debate, opening the "dialogue channel" with students. Such behaviour is fundamental to develop a "democratic attitude through mathematics education" (Skovsmove, 1994).

Freire (1997) also considers that the production of critical knowledge should be a unique work between the teacher and the student; and that correct thinking that surpass naive thinking, have to be built by the student himself together with the teacher and his /her partners.

Developing an attitude of respect in relation to the knowledge that the student acquired in his/her cultural environment and brings to school involves the discussion of topics like: the rivers and seas pollution, the low levels of well-being of different peoples, failures in the public health system, assistance policies, strikes, or unemployment, among others. These subjects are present in daily newspapers, television or magazines. It is obvious that the level of the knowledge about these themes should always be taken into account and we must consider and respect the age where the studies are being developed.

4 METHOD: MATERIALS AND PROCEDURE

A letter was sent to 10 educators inviting them to collaborate in this research, 5 teachers and 2 coordinators accepted. Thus, a study and research group of studies about Statistics and Probability in Children's Education (GEPEPEI) was set up in 2000; actually it is made up of five teachers, three course coordinators of Children's Education from a private school in Campinas and the author.

Since then, this group has been meeting every fifteen days to study the theoretical reference about the topic, plan and discuss teaching activities for classes and analyse the development of the students in terms of these activities. Part of the meetings were devoted to study and discussion of published research from some authors about the acquisition of stochastic ideas, especially Piaget and Inhelder (1975) and Fischbein (1975), who extensively studied probabilistic thinking

Data were collected by questionnaires, interviews, videotapes and tapes of the classes and meetings together with the teachers' written documents. The researcher's role was to promote the reflexive process and extend the teacher's professional knowledge.

The teachers' development was analysed, with particular emphasis on teachers' knowledge about statistics and probability and on the changes emerging from the intervention process by group members when training Children's Education teachers.

The progress in the teachers' professional development when teaching and learning statistics and probability at Children's Education level was significant

because the teachers created many teaching activities in which statistical and probabilistic thinking was present in the context of integrated projects developed during the whole year.

This research was continued in a PhD Thesis, including seven case studies, analysed according to the following categories suggested by Pontes and Santos (1998):

1. First category is the *Mathematical knowledge*, in this case the stochastic knowledge that the teacher has and the content taught.
2. The second category of analysis is *the teacher's professional knowledge* referring to the curricular knowledge about the topic.
3. Another category of analysis concerns *the student and the learning process*.
4. Finally, a category that is more linked to the teaching practices refers to the preparation, development and assessment of teaching and learning.

Data (observations, interviews, registers) was analysed according to categories built from the reflections about the materials created by the teacher, and considering the fundamental role that the theory has on this building process.

The analysis of data started with a careful reading of and reflection about the data collected. The role of reflection in teacher development, the relation with the curriculum and the collaborative work, which emerged, have also been analysed by triangulation.

Throughout the preparation and development of activities in stochastics, the teachers built up their pedagogical practices in different ways to widen their professional development. They wrote and published reports about their experience, learning about the relevance of a written register.

5 DISCUSSION AND CONCLUSIONS

In developing the teaching of stochastics, the teacher will need to think about avoiding determinism, besides updating and building their own knowledge about the subject. At the same time the teacher will visualize the fact that we live in a world that is simultaneously stochastic and deterministic (Davis and Hersh, 1988). Besides that, according to Godino, Batanero and Flores (1998), "a main point in preparing teachers in a specific mathematical topic is the epistemological reflection, which can help them to understand the role of the concepts within mathematics and other areas, their importance in students' learning and development, as well the students' conceptual difficulties using the concepts to solve problems".

These authors suggest this deep reflection is essential in the specific case of stochastics, which is difficult to teach. We should not only present different models and show their applications but we have to go deeper into wider questions, consisting of how to obtain knowledge from data, why a model is suitable, and deal with controversial ideas, such as randomness, luck or causality.

The teacher faces a bigger challenge in the process of acquisition of this knowledge, because they are giving students opportunities to explore questions and ideas that involve statistical and probabilistic thinking. It was visible that they were also building their own knowledge, which possibly influences their practice, when creating didactical situations.

Work with stochastics in the classroom must promote discussions and reflections to solve a problem-situation that was questioned by the students or instigated by the teacher. The teachers need to encourage learners to socialize their solutions, learning to listen to criticism, appreciating their own roles as well as that of other students.

Our research produced important contributions to research on pedagogical practice and mathematics teachers' professional development because it analysed the professional development of a group of teachers when teaching and learning basic notions of statistics and probability at Children's Education level. It also contributed to research on statistics education that emerges timidly in the elementary school. It also has shown some evidence suggesting that a different view of the teacher's knowledge and professional activity may be fruitful in mathematics teaching at elementary school level.

Teachers' autonomy to teach mathematics to children is fundamental, so that the efforts concerning knowledge of stochastics with mathematics teachers in elementary schools should be critical and reflective and be aware of the complexities of children's education.

When integrating problem solving into the mathematics curriculum of children's education and presenting their students with situations in different contexts, teachers practice an inherently complex and unpredictable context with its own specific characteristics that have to be valued. Teachers work within many constraints but still create quite sensible solutions for practical situations as they create new curriculum through their actions.

To be effective, research on teachers' professional knowledge should be collaborative, should promote the development of teachers' professional role, and should relate to children's cognitive development in the process of teaching and learning. Research in this field needs the strong participation of teachers where they are granted the role of active partners speaking for themselves (Jaworski, 1992). This collaborative process may be the most valuable key for better understanding and improvement of kindergarten teachers' mathematics education.

More results about this work were published in two books, including reports from the teachers involved in this research (Lopes and Moura, 2002, 2003).

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