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LEARNING OPPORTUNITIES IN A KINDERGARTEN ABOUT THE CONCEPT OF PROBABILITY

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Abstract
In this paper we describe the students' mathematical learning in a kindergarten during a classroom teaching experiment about the concept of probability. We present and analyze the learning opportunities that were created in the classroom as the children tried to resolve their problems, to reason mathematically and to communicate their thinking to others. The results of the research showed that kindergarten children made considerable progress in their probabilistic thinking, when they accepted the process of the experiment to check their different predictions as well as when they arrived at a consensus about the solution of a problem.

As a consequence of the constructivist epistemology, it is nowadays acceptable that the learning of school mathematics is a process in which students reorganize their mathematical activity to resolve situations that they find personally problematic (Cobb et al., 1991). Learning opportunities can arise for students from their personal engagement with the mathematical activities as well as from their interaction with the other members of the classroom. The teaching of school mathematics can be characterized as a process in which the students and the teacher negotiate their mathematical meanings and interactively constitute the truths about a "taken- as- shared mathematical reality" (Cobb et al., 1992).

This acceptable view has oriented research towards the construction of models that specify the development of children's thinking on concrete topics in mathematics as well as to the investigation of the role that interaction among the members of the classroom can play in cognitive development. However, many questions have to be answered for the organization of mathematical education on

subject matter specific knowledge and many researchers suggest that empirical data from real classroom settings are necessary.

Towards this effort, the purpose of this paper is to explore and analyze the learning opportunities that occurred in a kindergarten during a classroom teaching experiment concerning the development of probabilistic thinking. The concept of probability is considered as one of the most difficult in mathematics education, as many researches have shown (Shaughnessy, 1992-Kapadia & Borovcnik, 1991). The research reported in this paper is a part of a broader program that try to: a) investigate the range of the abilities that children can develop in the kindergarten on stochastic concepts, b) analyze the learning opportunities that are created in the classroom taking into consideration the cognitive and social processes involved, c) scrutinize the contexts of the activities that can be fruitful for students.

In the research program, we were based on current research literature about the development of student's thinking in probability (Jones et al., 1997- Jones et al., 1999) and these findings influenced the organization of the instructional activities given to the pupils.

Methodology

Fifteen kindergarten children were participated in the classroom teaching experiment in a typical public school of Athens. The research project was realized in November 2001 and it lasted one month. The children were engaged with mathematical activities related to probability three times per week. Every lesson was lasted half an hour. The program was realized in collaboration with an experienced and well-informed kindergarten teacher. In the course of the program we developed a set of instructional activities on the concept of probability concerning the following themes: sample space, probability of an event, probability comparisons and conditional probability. The instructional activities used in the classroom were developed before and during the progress of the program, according to the evolution

of the students' ideas, so that they could be problematic to the students. Moreover, all the activities were related with the interests and the experiences that children have at this age. More specifically, the activities were presented through games, small stories in puppet show and dramatic metaphors. A typical lesson could be described in the following way: The teacher introduced the instructional activity to the whole class, the children made their predictions about the concrete problem by explaining their thinking and the teacher recorded the different ideas of the students. Then, the children checked their predictions through the realization of an experiment, they recorded the results and they discussed about the solution of the problem.

The children had not received any previous instruction in probability. Moreover, they had not yet received any instruction in whole numbers. Each child was interviewed for one hour prior to the instructional program, at the end of the program and one month later. The interview included 14 tasks. The children were asked: a) to report the outcomes for a probability situation (for example, what could be happened by throwing a die with different colors), b) to predict the most likely outcome in a random experiment (for example, to predict which color is "the easiest" to be drawn from a box with colored balls), c) to chose the probability situation for the most likely realization of an event and d) to report the outcomes of an experiment, since they had realized one trial. All the lessons were videotaped. The transcripts of the interviews and the lessons provided the data for the analysis of the students' learning. Analytical descriptive narrative was the method used for our analysis (Erickson, 1986).

Results

Prior to the instructional program, all the children participated in the teaching experiment seemed to interpret the tasks in probability in a subjective manner. However, we could identify some qualitative differences in their thinking. More specifically, the students' responses could be classified in two general categories.

On the first category, the children gave answers that they were strongly influenced from their favorite color for all the tasks (4 children). Ada was a representative child for this category. She answered the red color as the only one that could be appeared in all the tasks. So, she reported only one outcome in a one or two stage experiment (e.g. she gave only one ordered pair in a two-stage experiment including the red color) and she insisted that the red color was "the easiest" to come out in all the experiments. Since she had realized one trial in an experiment (with or without replacement) and she was asked to describe the possible outcomes on the next trial, she repeated the color that she has got on the first trial.

On the second category, the children could give all the outcomes for a one - stage experiment. However, they gave only one ordered pair in a two-stage experiment. These children considered that they could not give another combination, because they had only three colors in the bag and so «it is only one that it is left over». That means that it was very difficult for them to understand the context of the task, as they considered that one trial of the experiment was identical with the solution of the problem. They could not imagine that for every trial all the balls could be again inside the bag. Furthermore, these children did not have a consistent way of thinking to answer the tasks for the probability of an event, sometimes they gave a right answer and sometimes they gave a wrong answer. However, in all cases it was very difficult for them to provide an explanation for their answer. In the case that they presented their arguments, they seemed to be influenced by the position of the materials or their favorite color. In the comparison probability tasks, they gave usually the right answer for the probability situation related to spinners and a wrong answer for the one related to boxes with balls. Since they had realized a trial in an experiment, they did not usually mention the color that they picked, but they gave all the other outcomes.

The following episodes were selected for analysis as they represented critical moments in the students' learning. In these incidents that took place in the

classroom, learning opportunities were created as the children tried to resolve their personal problems or to communicate their thinking to others and to justify their position/solution to a problem.

First episode

The children were engaged in the following activity (This was the second activity about the probability of an event): The grand mother and the grand father of the squirrel would like to make a scarf for him. The grand mother found a bag with balls of wool with different colors (1 blue and 3 green). As the grand mother and the grand father were in complete disagreement about the color of the scarf, they decided to pick a ball at random. The children were asked to predict the color that was "the easiest" to come out. The following dialogue took place between the children:

Anna: The green, because there are 3 green.
Teacher: Is there another opinion?
Socrates: The blue, because it is higher up in the bag.
Teacher: What do you want to say Paul?
Paul: I say the green ...we close our eyes and we pick a ball.
Teacher: Paul said that we close our eyes when we pick a ball. So, we cannot see which it is up. As we are picking a ball, we can mix the balls. *(He is doing the movement.)*
Socrates: It is the blue one, because the two green are below.
Anna: It is the green, because there are more. Let's do it.
Socrates: Yes!
Teacher: OK! Let's do it.

Anna, Paul and Socrates were three of the children whom their responses at the interview could be classified on the second category. However, in the progress of the program Anna's responses were based on quantitative judgments, she used the words «more» or «less». It was the first time that she used numbers to justify her answer. On the other hand, Socrates was still influenced by subjective judgments, when he tried to justify his answer. The level of Paul' s thinking about the probability of an event could be characterized as transitional (Jones et al., 1997), between subjective and naive quantitative thinking. In this episode, as he tried to justify his answer, he based on the process that they used to make the experiment, and he used an argument which could upset Socrates' argument. This argument seemed to be a fruitful contribution for the development of Socrates' thinking.

Although Socrates insisted to his answer, when Anna told him that they could find the solution to their problem by executing the experiment, he willingly accepted her idea. This was the first time that the children legitimated a way to resolve their disagreement by respecting the results of the experiment. Until now, there were children like Socrates that they insisted to their solutions even though they knew the results of the experiment. After the realization of the experiment, Socrates changed his opinion. In this sense, this incident was functioned as a catalyst for the following lessons.

Second episode

In the following episode, the instructional activity was related with the different ordered pairs that the children could make in a two-stage experiment. The children had to construct Christmas cards with two flowers in order to help the Father Christmas to share them to the children together with his presents. The children had to pick one color from a box with three colors to paint the first flower and they had to put it back. Then they had to pick again one color for the second flower. After painting the flowers, they should discuss how many different cards they had made.

It was the turn of Thomas to pick the two colors. After picking the first color (it was the red one), he picked the second one. This was also red. Thomas told to the teacher with surprise that this could not be happened, because «we have to chose two different colors». The teacher tried to pose Thomas' thoughts as a topic of discussion with the rest of the class.

Teacher: What are you saying? Thomas said that this is not right.
Anna: Yes, we cannot have the same color.
Ada: But, this color came out.
Teacher: Ada said that we pick the colors at random. So, can we have the same color twice?

Thomas raised his shoulders puzzled. The teacher did not continue the discussion and the children went on with their work. When they painted the cards, the teacher asked them to find the cards that were the same. The children began to put together the same cards, that is, the cards with the same colors. So, they began to

put together the cards with the red and the green color. On the next card, the first flower was green and the second was red.

Teacher: Where will you put this card?
Thomas: Here. *(Together with the other cards)*
Anna: No, this is different. It is firstly the green and then the red.
Socrates: This is wrong. They are not different. They are the same.
Thomas: It' s a little different!
Socrates: Yes, it's a little different.

Teacher: OK. There are not the same, however they are a little different, so can we put this card alone, not with the others?
Thomas: Yes, here. *(He is showing a place near to the other cards).*
Teacher: Can we make other different cards?
Anna: Yellow, red.
Teacher: OK. We have the red-yellow card and we can make the yellow-red.
Marina: Two green.
Teacher: Very nice.
Thomas: Two blue.
Teacher: Bravo, Thomas.

On the above episode, as the children tried to negotiate their different interpretations about the word « different» in the concrete context, they managed to resolve their conflict and to construct an acceptable characterization of the difference of the cards. In this manner they managed to find all the different ordered pairs in subsequent similar activities. Moreover, the argument that Ada presented, showed that she had accepted the notion of random and seemed to influence implicitly Thomas' thinking about the possibility to have the same color twice.

Third Episode

The third episode is presented in brief. It is connected with the probability of an event, when all the events are equally likely. The children had to pose their own problem to be solved about the probability of an event.

Paul: I want to give a notebook to Kostas.
Children: What color does Kostas like?
Paul: The red. (*He is putting in the box, 2 red, 2 green and 2 blue notebooks*).
Teacher: Which color is the easiest to come?
Anna: The red.
Paul: No. It' s easy to come the red and the green and the blue.

Although the teacher had not discussed with the children until this episode probability situations with equally likely events, this problem arose from children's

attempts to make their own problems in probability. In this way they provide to us the opportunity to discuss with them similar activities like fair and unfair games.

We should note that at the final interview all the children had done a real progress in their probabilistic thinking. The majority could report all the outcomes in a two-stage experiment and use quantitative arguments to justify their answers.

Conclusions

The results of the research showed that kindergarten children made considerable progress in their probabilistic thinking, when they accepted the process of the experiment to check their different predictions as well as when they arrived at a consensus about the solution of a problem. However, more evidence from different cultural kindergarten classroom settings is needed to investigate the critical incidents that influence children's probabilistic thinking at this age.

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