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Teaching Probabilities and Statistics to Preschool Children

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This study considers the teaching of probabilities and statistics to a group of preschool children using traditional classroom activities and Internet games. It was clear from this study that children can show a high level of understanding of probabilities and statistics, and demonstrate high performance in probability games. The use of Internet games in the teaching of probabilities promotes the teaching and learning process to preschoolers.

Little recent research has been done in the field of teaching probabilities and statistics to young children, although some very interesting articles on learning probabilities were written during the 1960s. Lewis (1966), in his experiment with a binary-choice problem demonstrated that in preschool and elementary school children, age and intelligence do not result in better performance, but sometimes can result in poorer performance. He explained this phenomenon by the fact that binary-choice behavior does not involve a conscious decision making process. Bogartz (1966) investigated the ability of preschool children in alternation prediction and the variables influencing alternation prediction. In his research he showed that there was relatively poor performance on the part of kindergarten children, in an experiment with nonalternating recurrent sequences, due to children's limited sensitivity to contingencies. Additionally, Reber and Millward (1968) showed that "for probability learning to occur it is not necessary that subjects make a prediction response." All of these studies suggested that preschool children are able to understand probabilities, and they can talk about probabilities with

their teacher. Sherwood in his "e-publication," posed the question "at what age can children begin to grasp principles of probability?" and he suggested that a lot can be done before the age of 11 years because the children have an intuitive way of thinking and answering where probabilities are concerned.

Recent studies in the area of learning probabilities and teaching statistics have shown that children are able to understand basic probabilities and statistical concepts because they can use them in their every day activities (Shaughnessy, 1992, Schlottmann, 2001). Especially, Schlottmann, (2001) in her recent article concerning the children's intuitions of probability, suggested that "it appears that children acquire the expected value intuition in their every day life, a concept functional by the time they start school and before formal instruction with probabilities" and "probabilistic reasoning… should not be overlooked."

Although it is fairly clear from many studies (Lewis, 1966; Offenbach, 1965; Schlottmann, 2001) that probabilities and statistics can be introduced to young children, elementary school curricula in Greece have only one or two chapters about probabilities and statistical applications, such as, sorting objects into classes by different criteria, or by calculating the mean, or by drawing bar charts. Moreover, for young children in kindergartens, special activities in probabilities and statistics were not found in preschool curricula, only a few ideas such as sorting objects were embedded in the mathematical activities. Unfortunately, most preschool teachers in Greece, have little or no background in the mathematics associated with calculating probabilities and interpreting statistics. Historically, teacher preparation programs in Greece, have not systematically included probability and statistics courses. Therefore, in order for the children to be adequately prepared to make predictions, preschools need to pay greater attention to probability and statistics.

According to the theories of learning, children could learn through social interaction, real-life situations, (Piaget, 1952; Vygotsky, 1978), activities which heighten students' self-awareness, actions, forms of self-expression, writing, playing with dice, cards, and other games. Today we could also include in this process, the video games and the games on the Internet. The Internet is, paradoxically, both a physical and virtual embodiment of computers and people. In particular, it is a social construction, where children can live, play, work, and learn, so it can be used for teaching probabilities and statistics. Direct manipulation can be incorporated between the real-world, and abstract representations to support the transition from simple to novice thinking of probabilities.

The aim of this study was to emphasize an effective teaching process to teach probabilities and statistics to preschool children, using simple experi-

ments with probabilities, as part of classroom activities and Internet games. Collaborative learning techniques and new technologies were also applied in this teaching process. The age and gender effects were not examined in this study, as other authors have studied them explicitly (Lewis, 1966; Stevenson & Weir, 1959).

MATERIALS AND METHODS

Subjects. 17 children, 7 boys (41.2%) and 10 girls (58.8%) from the Experimental Preschool in Ioannina, Greece were used for the preschool children group in this study. Their ages ranged from 4 to 5 years (mean age = 4.6).

Procedure. The children were split into groups of five, six, and six children. To introduce probabilities and statistics to preschoolers, these simple experiments were used:

- by throwing one coin in the air and by asking them to think about the outcome of this throw and to guess the next one. To promote further concept development, they were asked which was more likely to happen: Both Heads, Both Tails, or one of each. Of course the children acted this out many times and the data was recorded. Then they discussed the outcome with their teacher in the class; and
- by throwing a bar with two colored ends (black/white) in the air. The children had to find, which end their teacher was holding.

For the statistical part children had to count the balls with three different colors and put them in lines according to their color to make simple statistical diagrams.

The Internet experiment. In this experiment the three doors probability problem was used. The three door problem was an Internet game where children had one in three chance of finding the hidden car. In this game there were three closed doors and behind one and only one of these doors there was a car. Behind each of the other two doors there was a goat. The children had to click on the door behind which they thought the car was. (http://math.ucsd.edu/~crypto/Monty/monty.html)

For teaching purposes, the children had to play with this game after their play with the dice. Their preschool teacher showed only how to play this video game using the computer and then she explained about the proba-

bility of getting the right answer (1/3).

Learning environment. For the purpose of this study, the constructivism theory was used. This theory of learning, (Piaget 1971) has been widely accepted in education communities. This theory describes learning as actively constructing one's own knowledge. We can apply this theory for research and reform in mathematics and science education. According to constructivists view, students bring to the classroom their own ideas, experiences, and beliefs. Students or children are not "receiving" material in class as it is given, but reconstruct the new information to fit into their own cognitive frameworks. In this case, children had their own ideas about probabilities, and they reconstructed them after the experiments were done in the classroom using the technology as well. According to Ferguson (2001) "using technology as part of a constructivist philosophy in a classroom, children can be given a powerful set of tools. Computers, video, and other technologies engage children with the immediacy they have become accustomed to in their every day lives."

RESULTS

In the first group of five children there were randomly assigned three girls (Mary, Alkistis, Zenia) and two boys (Haris and Peter). The dice was tossed in the air by the teacher and the children started to guess the outcome: Mary said "tails," Alkistis said "heads," Zenia said "heads," Haris said "tails," and Peter said "heads." The outcome was "heads." The teacher wrote the outcome on the blackboard. Haris and Mary were disappointed. She repeated this process and all children guessed "heads" for the next outcome. When she tossed the coin, the outcome was again "heads" and the teacher again wrote the outcome on the blackboard. So, the children were almost sure that the next outcome must also be "heads" and all said "heads." But the next outcome was "tails." This time, they were confused and then the children started thinking that sometimes we "are not sure" about the outcome but we can try to predict it. Every time the teacher wrote the outcome on the blackboard, to allow children to see the sequence of the outcomes and to help them guess the next outcome. After this experiment was repeated 10 times, children realized that it was almost impossible to find what was the next outcome of tossing a coin, whether these could be "heads" or "tails," but in a fair game they could predict that outcomes were almost 50-50. The teacher stopped tossing the coin after the 10^{th} repetition because children were starting to loose their interest. During this experiment, she discussed

fair and non-fair games and the children were convinced that the procedure in the experiment was absolutely fair. Then, the teacher started talking with the children about what way the concept of the probability and the random experiment differs from another process, for example the counting process. She used simple examples from their everyday life. Then the children had to find and explain where we use the word "possible" in everyday activities, (for example in the weather forecast, for the winner in football, etc.) and what we mean by this. The answer was quite clear and they said that: "when we say possible we mean that something may happen or happen not." So, these preschool children showed conceptual understanding of probability and its meaning became familiar to all (although only one girl, five-years old, from the beginning of the experiment said that "we cannot predict the possible outcome.") She was the only one who used these words.

This process was later repeated for the other two groups of children and the teacher got similar answers. To let children "learn by doing" the teacher opened the Internet address with the three door problem and asked them—in groups of three and one of two—(because there were three doors) to play this Internet game. The teacher was in the same place supervising the children but not directly involved in this process. Children were allowed to play the game as long as they wished. As was expected, children who were more familiar with computers started first, but later all children entered into this process. It was interesting that during this process, the children had taken the teacher's role and they were asking their friends "where do you think the car is?" The children who found where the car was for the first time during the game, they pointed at the same door, in the next two games, and when they later realized that the car was not always behind the same door, they then changed their minds and started thinking in which of the other two doors the car could be behind. It was observed that although children had played the game with the coin before, in this Internet game they made the same mistake in finding the car, because they pointed again and again at the same door where the car was, for the first two or three times! But, to their amazement the car was sometimes behind the same door! So, in their following predictions they tried to find where the car was irrespective of the previous game. In doing so, they involved themselves in this computer game and they found it an interesting one, because it was noticed that they did not stop at the 10^{th} repetition of the game as before, but they continued for quite a long time. It was clear that this game made them understand better that in order to find the car "we can bet on different doors if we like" and not "on the door behind which it was before."

Playing an Internet game, children did not get bored or lose concentra-

tion as they were actively participating. The most interesting thing in this process, was that all children were more enthusiastic about this game than the previous one (tossing the coin), because:

- behind the doors the pictures were more interesting;
- they could play it as many times as they liked;
- they could do it by themselves;
- the game was fair (for sure) because the teacher did not interfere.

In their discussions during the Internet game they said:

- "there is no rule to tell us where the car is;" and
- "we must try many times in order to find the car."

After these two experiments the teacher played a game with a bar, which was at one end black and at the other white. Both ends were covered with a piece of paper and after the bar was thrown in the air, the children had to guess which color was behind the end the teacher was holding.

In this experiment it was found that children understood the different possibilities and the totality of the events because they said that "this end is probably black/white" irrespective of their previous answer. In all games the children were guessing the outcome and were trying to make the predictions for the outcomes without thinking of losing or winning in the game after the first two or three trials. The main benefit of the previous example with the coin was that it helped them understand a binary process and in the Internet game experiment, they were ready to say "the car cannot always be behind the same door." In all these experiments for teaching purposes children were allowed to work cooperatively. The idea behind this approach was that when children worked in groups, they became less bored on new subjects than when they worked alone with their teacher.

From the other experiment with the statistical diagrams it was clear that children did not find any difficulty, in splitting balls into groups and then counting them and drawing diagrams. Children, during their every day activities in kindergartens, count toys and split them into groups according to their size or count flowers and split them into groups according to their color or size. So this process of drawing bar diagrams was quite simple for them. The only difference was that children had to join the upper end of each bar in order to draw another line diagram. For teaching purposes, their teacher also used the computer to draw all these diagrams again. So, the children put the balls on a two-way table drawn by their teacher using "Word document," as it is shown in Figure 1. In these computer diagrams,

children easily repeated the process that was previously done in the classroom.

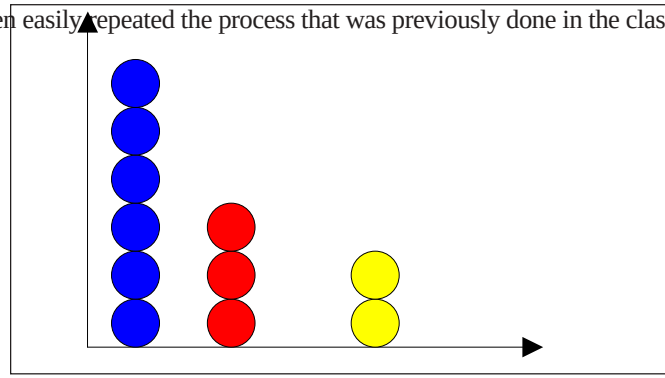

Figure 1. Diagram with balls

THE TEACHER'S ROLE

The teacher in these experiments engaged all children in the learning process; all children had equal opportunities in learning about probability and statistical terms using computers and the Internet games. The teacher, in the first experiment with the dice, helped them understand the binary process, explaining what the possible outcomes in a binary process are and the random sequence of the outcomes. Later, in the other experiment with the Internet game, the teacher helped them to work independently with probabilities, although in some cases some children needed more support than others. In this case, when children got the teacher's role, the experiment became more interesting for them, they worked in groups and they were the master of the game. So they showed an intuitive understanding of probability that was clear from their discussions in the experiments:

- "this time it will be heads,"
- "the car is either behind this or on that door,"
- "it is not so easy to find the car,"
- "we do not know what the outcome of this experiment will be," and
- "there is no rule to tell us where the car is, sometimes it is here other times it is there, and so forth."

Collaboration in the Internet game and their discussions about probabilities, were important in promoting their thinking of probability. It is also im-

portant to note here that when one girl was saying during the experiments, that “we cannot predict the possible outcome,” the teacher had to help her to use the words “predict,” “possible,” and “outcome” in the right order with their right meaning because all outcomes are possible!

During the last experiment with the bar it was quite clear that children became familiar with the probabilities from the Internet game and they did not find any difficulty in the bar game. Of course the fact that this was the third game with probabilities, played a role, but children’s answers showed that they understood the abstract concept of probability.

One also has to consider the importance of teaching statistics using simple diagrams. Children like drawing bar diagrams. They can even draw them on the computer. Moreover, teachers in preschools are familiar with counting and drawing activities, but they are sometimes not able to connect these activities with statistics.

The teachers have to be well prepared during their undergraduate studies, in probabilities and statistics, to teach a course like this to children. The school curricula have to reorganise their chapters and include among others, simple binary games, experiments with more complex probabilities, and bar or line charts.

DISCUSSION

The results of the experiments with probabilities for preschoolers in The Experimental Preschool in Ioannina, agreed with the findings from other researchers (Stevenson & Zigler, 1958; Stevenson & Weir, 1959), where their studies with young children showed a high level of performance in experiments with probabilities. Moreover, it appeared from their discussions with their teacher, that preschool children took probability as an abstract meaning and not as a physical one.

In this study it was also clear that although the amount of time needed for searching the Web for sites with probability examples for children, is sometimes time-consuming, the gains were multitudinous. The main benefits of the Internet game with probabilities, were the following: it excited preschoolers’ curiosity, aroused their thinking, promoted children’s reasoning and made teaching more interesting. This teaching method is considered a very efficient one, because during the teaching process, children played and learned about probabilities and started thinking of an uncertain world.

In the Internet games with probabilities it is also important for the teacher to consider only these skills practiced, which are closely related to the probability ideas being taught to children in the classroom. According to this method, the preschool teacher should focus on the understanding of the

events, rather than on the playing—winning or losing—of the Internet game.

In conclusion, it becomes clear from this study that; preschool teachers have to incorporate the power of the Internet in their classes, because many kindergartens in Greece and elsewhere, will soon have access to the Internet. The only problem in Greece is that very few teachers in our kindergartens know how to evaluate the Internet material on probabilities and how to teach probabilities well. This is due, either to their misconceptions of probabilities or to their lack of knowledge about children's preexisting conceptions related to probability and statistics. To avoid these obstacles, the teachers have to be educated or reeducated on these subjects, and new technologies need to be included in the teaching process. The increased awareness of the impact of the Internet, probability, and statistics, has to be included in the preschool curriculum.

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WORLD WIDE WEB RESOURCES

http://www.wku.edu/~neal/probability/prob.html
http://www.maths.uq.oz.au/~pkp/probweb/probweb.html
http://lrs.ed.uiuc.edu/students/mcornell/cerealbox/index.html
http://www.mathgoodies.com/lessons/vol6/intro_probability.html
http://math.ucsd.edu/~crypto/cgi-bin/monty2?1+1729
http://www.stat.uiuc.edu/~stat100/java/Monty.html