Why is it necessary to teach probability from kindergarten onwards?

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Abstract:
Probabilistic intuition does not develop spontaneously, so one has to train it and start from the initial level. Initial education encourages the development of different verbal expressions: expressive, physical, communicative, symbolic, playful, cognitive, ethical, affective, metaphorical, logical, imaginative, and relational, among others. This experience was developed in a school in the city of Rosario where a professor of statistics worked alongside teachers and children in their classes. They began by raising the issue of probability, playing with the possibilities of actions where probability intervenes in their daily lives. They were presented with trees of possibilities from the moment they got up to go to school: breakfast, what it consisted of, who was taking them to school, etc. They started playing with colored cards and mentioned possible and impossible events. This paper presents examples of games and how the children solved them. The results were highly satisfactory as the children were able to sense intuitively that chances were present in their games and thus extrapolate them to other situations. Based on participant observation, the teachers evaluated the language acquired by the children and how variability began to internalize in their thoughts, considering that it is possible to introduce the concept of probability from games and everyday situations. A good teacher needs to know the importance of teaching probability at this level, as it will train a child able to think not only deterministic but also probabilistic, which will allow him to advance towards a critical spirit fundamental to his future development as a citizen.

Keywords:
Probability; Initial level; Intuition; Games; Teaching

Introduction:

Internationally, mathematicians consider incorporating non-deterministic thinking, since life is rooted in randomness in all its facets. Díaz Godino, Batanero, & Cañizares (1996) support this position, arguing that an efficient scientific culture requires an education in statistical and probabilistic thinking. Thus, a new concept of statistical literacy emerges. There are several studies on the importance of starting probability and statistics education very early and that children have the ability to develop their thinking if teaching is embedded in their world.

Studies on the key role of early education in probability

- According to Gal (2002), statistical literacy is the ability to interpret data, critically evaluate them, and, if possible, express opinions about statistical information and shape arguments related to data or stochastic phenomena. Gal defines probabilistic literacy as the ability to access, use, interpret, and communicate probability-related information and ideas, to effectively participate in and manage the demands of functions and tasks involving real-world uncertainty and risk.
- According to Piaget (1975), children gradually understand their surroundings, improving their sensitivity to contradictions, performing mental operations, understanding

transformations and acquiring new notions, trying to adapt to the world around them. When a new idea turns up that clashes with existing ones, it creates a cognitive conflict or imbalance in the child's mind. Learning is therefore conceived as a process of adaptation that organizes the real world of experience. Piaget and Inhelder (1951) consider that the learning potential depends on previously acquired knowledge and on the intellectual development of the child, which is achieved in stages that determine evolutionary development.

Piaget and Inhelder focus on the pre-operative period of 3 to 5 years, i.e., kindergarten, characterized by the need to manipulate real objects to learn a certain concept, since children rely on their empirical experiences for their understanding. They understand the organization of space, they start to count small numbers of objects and estimate, from a quantity, length, volume and weight. They are able to order events in time (knowing what happened before and what will come after).

- Fischbein (1975) showed that children have partially formed correct ideas about probabilistic concepts and analyzed the effect of teaching to improve these intuitions. Fischbein (1987) considered these intuitions as cognitive processes that intervene in practical or mental actions with certain characteristics: immediacy, globality, extrapolative capacity, structuring, and self-evidence. Immediacy means that intuitions are not reflective, but often arise spontaneously and serve to make predictions.
- Shaughnessy (1992), Jones, Langrall and Money (2007), and Dodino (2009) conducted further studies on how kindergarten children approach probabilistic reasoning.
- Batanero (2013) argues that children should start learning the first knowledge related to data analysis and chance right from the initial level.
- Alsina (2017) considers three reasons for introducing statistics and probability at the initial level: it guarantees a quality education adapted to social changes, it highlights the teaching of mathematics, and it shapes the literacy in this field.

These studies allow us to affirm that in today's society, children must be trained from the initial level in their integral development so that they can interpret all the information presented to them and analyze the probabilities of occurrence of events in their daily lives.

Suggestions how to teach statistics in the early phases

Therefore, the question how to teach statistics from kindergarten onwards must be pondered on.

- Bandura (1982) considers that when the child learns through his own experiences and activities and if the situations presented are significant for him, learning arises spontaneously without the need for extrinsic motivation. Active learning involves interacting with the environment and the people around the child, it can be done individually or in groups, and involves cooperation and collaboration. These interactions lead to experiences in children that modify their present and future behavior.
- Serrano (1990) affirms that learning is an active process "in which the attention, memory, imagination, reasoning that the student carries out to elaborate and assimilate the knowledge that he/she is building and that must be incorporated in his/her mind in defined and coordinated structures. Fischbein argues that probabilistic intuition does not develop spontaneously, it has to be "trained" from the earliest schooling.
- Steinbring (2005) considers that the teaching of statistics in schools overarches the mathematics curriculum, providing opportunities for the use of mathematics in applied contexts and should be included in a specific teacher training program: statistics didactics, computer work, mathematical modeling of situations with elements of uncertainty, and project work based on the principle of "learning by doing".
- Batanero suggests that children can acquire probabilistic notions through activities based on games of chance, which favor their intuitive acquisition. For her, chance equates to unpredictability; and when the number of possibilities is small, the primary school child reasons correctly.

When Argentina's 1993 Education Law was enacted, statistics was incorporated into mathematics curricula, which posed a major challenge for teachers, who did not have the adequate training in statistics.

Methodology:

In its beginnings, to support the task of teaching statistics, Santa Fe Province implemented courses. The present author was appointed Professor of Statistics at the Teacher-Training Institute and taught training courses in statistics at different levels. Most of the pre-school and primary teachers attended to inquire about the methodology to be implemented. The 2006 National Education Law modified the education structure, the first level becoming now initial education.

Initial Education as a constructor and transmitter of culture will enable children to explore and attain the world beyond their affective learning household, while playing: it promotes training through the development of all their languages: expressive, corporal, communicative, symbolic, playful, cognitive, ethical, affective, metaphorical, logical, imaginative, and relational. Here the teaching they receive on the first statistics and probability notions plays an important role.

Then, university statistics professors were summoned to train the teachers. The present author was one of them. Guided by the proposals of the National Council of Teachers of Mathematics (NCTM 2003), we taught statistics to kindergarten teachers with amazing results, then to initial-level teachers, and finally to high-school mathematics teachers.

Such proposals suggest:

- Development and assessment of data-based inferences and predictions.
- Probability basic concepts understanding and application.
- Discussion of probable and improbable events related to students' experiences.
- Statistics and probability contents for 3 to 8-year-old children i.e., identification of simple data and facts from their close environment from discrete variables (e.g., collecting the weather of each day: sunny, cloudy, sun and clouds, rain).

When we started teaching entry-level teachers we were disoriented as to what to teach and how, but in the first class when explaining the definition of statistics and its scope, the teachers guided us to those applications that they could implement in their classes.

Currently, we continue teaching in kindergarten where we first teach the teachers the basic notions of probability and as a second step, the teachers prepare their classes by applying the notions learned in games. In these classes, we collaborate with the teachers in the building up of an atmosphere of mutual cooperation, where the child learns by playing.

So in each class, we taught them and they applied their learnings in their classrooms. There were ways to collect information through drawings and sticks, e.g.: at the beginning of the day the teacher drew figures of a boy and a girl and marked how many were missing, or at the end of the month the children looked at their notebooks and counted the sunny, cloudy and rainy days.

Result:

In the specific case of statistics and probability, manipulative materials can be a good resource for data analysis and for conducting randomized experiments.

Once we went with teachers and pupils to a children's farm, a place full of farm animals and they even made a double-entry table after their visit. This experience allowed us to understand how different teaching methods can be introduced at the initial level as a starting point for the progressive development of more complex concepts. We present an experience developed in a school in Rosario, Argentina, where we acted as a teacher of statistics teaching in the classroom to kindergarten teachers who were with their children, so there was a teacher-teacher-child interaction. Many activities were carried out while playing, among which we mention:

Activity 1. What do I do from the moment I get up until I arrive at school?
The teacher asks the children what they do from the moment they wake up and teaches them to make a tree diagram, indicating the possibilities for each action and so each child marks the options that are presented by pasting photos of all the steps they take to get to school. The word “possible” arises intuitively among children who, guided by the teacher, can differentiate between what they did and what they might have done. In their notebooks, they paste the possibilities for each action and highlight the chosen one. They compare their tree diagrams and discuss their choices with each other.

Activity 2. We play with colors
The teacher puts candies of different flavors identified by color into a bag. Each child should take out a sweet and observe its color. The teacher asks them to paste their candy wrap into a place assigned for that color on a poster on the floor. After all the wraps are pasted, a graph is formed. The teacher places the poster on the board so that together they can complete it, analyze the results, and reach some conclusions: What is my chance of eating a red sweet (strawberry)? Why are there no violet wraps (grape)? What is the possibility that a child gets purple wraps? The idea of “impossible” appears for an event that has no possibility of occurring. The teacher may ask whether it is possible to pick up a mint candy if all the candies in the bag are blue (mint); thus, the intuitive notion of a certain event arises with the possibility of always occurring and an impossible event with zero possibility.

Activity 3. We play reading a table on farm animals and company.
The teacher hands out sheets to the children with photos of a horse, a cow, a pig, a hen, and ducks and tells them to make a stick next to the corresponding animal on the sheet every time it is mentioned in the story of the farm that will be read aloud to them. The teacher reads the story several times emphasizing the name of any of the above-mentioned animals. Then, the teacher asks, which animals were tagged and which were not and why. The children begin to visualize, which animals represent the majority, which are the minority, and which are not in the story. Thus, the intuitive ideas of possibility, greater possibility or no possibility arise again.

Activity 4. How are we this week?
The teacher asks the children to denote their emotions over a week by pasting emoji faces that identify their emotional state every day of the week. They analyze how many were happy, sad, or angry, and the teacher asks, which face is more likely to come out next week based on what they plan to do.

Activity 5. Who will be the winner? Game of geese in the classroom.
The class is divided into red and blue geese. Each child throws a die so that their geese can move forward on a board and the group that reaches the finish first will be the winner. The movements will be plotted on a chart. The teacher shows them how the numbers when rolling a die can vary from 1 to 6, that the roll of a die is independent of what happens when they roll it again, that number 7 has no possibility to come out. Intuitively, the children already know the idea of a random experiment, a certain event, and an impossible event.

Activity 6. Heads or Tails
The teacher takes a coin and shows them its two faces: heads and tails. Each child flips the coin and marks the result on the drawing on the board made by the teacher. They repeat this activity 5 times and observe that the heads and tails graphs are coming closer and closer, allowing them to observe the similar possibilities intuitively, which shapes their first understanding of statistical regularity. The notion of randomness also applies in this experiment, since we cannot know the result before the coin is flipped. We emphasize that when the coin toss is repeated under equal conditions, the results vary, despite the constant conditions under which the experiment is carried out. Thus, they intuitively observe that in each random experiment the result is unpredictable.

Activity 7. What shape and color do we make more?
The teacher hands out doughs of different colors and different shaped cookie cutters. They pretend to cook and prepare cookies with doughs of different colors and different shapes. Once baked, the teacher records, of which one we got more taking into account both color and shape.

Activity 8. How do I go to school?
The teacher asks the pupils how they get to school. They paste the drawings of the means of arriving at the school – properly made by the teacher – into a poster: walking, cycling, motorcycle, car, bus They again analyze the possibilities according to who lives near, or far, and whether the parents have a car, a motorcycle, or a bicycle, and this intuitively reinforces the idea of possibility.

Activity 9. Guessing the weather for next week
The teacher proposes to bring a drawing with the days of the week and the weather for the next week, so they can intuitively analyze the possibilities, events, mutually exclusive events, among others.

Discussion and Conclusion:

In short, the objective of these classes is for teachers to consolidate:

- The use of the most basic and descriptive techniques for the treatment of random phenomena, such as tables and tree diagrams;
- The activities for a random approach based on the analysis of data collected from random experiences;
- The data collection activities for the intuitive calculation of probabilities; activities that propose to make a decision based on the analyzed data, assessing the margin of uncertainty.

Alsina and Planas (2008) affirm that games encourage active participation and induce knowledge sharing with others, essential aspects in building meaningful learning.

The work in class with teachers and children leads us to affirm that probability through games allows the child to start from intuitions and it is the teacher who should encourage these intuitions to be transformed into concepts where the teaching of probability based on possibilities plays a key role and allows to start developing non-deterministic thinking at the initial level.

Our own teaching practice leads us to think about teaching probability through games to deepen the first intuitions that arise spontaneously in the child, in a spiral way, so that the child begins to grasp the first notions of probability and can express them through non-deterministic thinking.

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