

### Statistics and Probabilities Theory in Russian school

- Historical review and background
- Federal educational Standards 2004 and 2010
- Concept framework on developing ME (2013)
- Exemplary curriculum 2016
- Federal Standard '19 (project, to be approved on Dec )

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### Controversy P.Nekrasov VS A.Markov



#### Journal of Ministry of public education #2 – 10, 1915

#### The first textbook on probability

E.Bunimovich, V.Bulychev

Probability and statistics, 5-9 and 5-11

Translation from a French origin

Year 2002



### The first mention of statistics and probability in Federal educational documents

Standard 2004:

'Elements of algorithms, combinatorics, probabilities theory and statistics'

No clear content

### The first regular textbook on probability and statistics

2004 Yu.Tyurin, A.Makarov and others For 7 – 9 th grades (high junior)

Based on new principles formulated after deep analysis

- desirable goals;
- reachable goals;
- flaws and mistakes in teaching



#### **Basic principles**

- 1. Starting with statistics in 7<sup>th</sup>
  - Data representation (based on charts and tables from el.school)
  - Descriptive statistics (central and scattering measures)
  - Random changeability and random phenomena in everyday life
  - Regularity and stability in random changeability as a matterof-fact phenomenon

#### Basic principles

- 2. Non-combinatorial approach in probability (since 8<sup>th</sup>)
  - Probability as 'a measure of likelihood';
  - Not overestimating the role of experiments with equally likely outcomes;
  - Not overestimating the role of combinatorics;
  - Intuitive probability based on the concept of 'a random experiment';
- 3. Clear connection between probability and statistics as much as possible;
  - The law of large numbers as one of the main goals.

#### Methodological and didactical support

- 2008 The first educational laboratory was open in MIOE (later attached to MCCME)
- 2008 The first Olympiad for students of grades 6 11
- 2008 2009 Yearly assessments on S&P for 7<sup>th</sup> and 8<sup>th</sup> grades in Moscow
- 2010 First problems on probability appeared in National Exam after high junior school

#### Methodological and didactics support

- 2011 Site 'Probability in school' <u>http://ptlab.mccme.ru</u>
- 2012 Probability had been introduced to National Unified Exam (after high senior school)
- 2015 Yearly assessment for 10<sup>th</sup> grades (two levels)

#### Legal and State support

- 2010 The Federal Standard revision includes items on S&P
- 2013 The Concept of Developing Math Education in Russia (Gvtl doc) announces S&P as ' an inalienable part of mathematics in school'
- 2015 The first exemplary curriculum containing detailed didactic elements on statistics and probability for junior school
- 2016 The same for high school
- 2019 (in progress) New Federal educational standard for junior school with S&P as an essential part of the content

#### FES 2019 (HJ, basic, fragment, project)

Expected results of 7 – 9 years of study of the subject "Mathematics" should reflect the formation of skills:

- Using tables, charts, graphs to represent real data, describe the dependencies of real quantities; understand the role of random variability in the world, to recognize changeable (random) values, in particular, the results of measurements;
- Using statistical characteristics to describe sets of numeric data: the arithmetic mean, the median, the highest and lowest values, the span;

#### FES 2019 (HJ, basic, fragment, project)

Expected results of 7 - 9 years of study of the subject "Mathematics" should reflect the formation of skills:

- Operating with concepts of random experience, random event, the probability of random events; finding the probability of random events in experiments with equally likely elementary events;
- Understanding the role of the almost certain and practically unlikely events in nature, science and everyday life;
- Operating with concepts of union and intersection of events, the opposite event, independence of events;

#### FES 2019 (HJ, basic, fragment, project)

Expected results of 7 - 9 years of study of the subject "Mathematics" should reflect the formation of skills:

- Solving the simplest problems on search of probabilities;
- Estimating probabilities of real events in the simplest situations;
- Understanding concept of random values and their numerical characteristics; the role of the LLN in the nature and in human life.

#### FES 2019 (HJ, advanced, fragment, project)

Deeper learning plus:

- Euler-Vienn diagrams, probability trees;
- Combinatorics in probability (permutations, combinations and random choice from a finite set);
- Random values, mathematical expectation, variance, binomial distribution and its characteristics, concept of LLN, based on Chebyshov's inequality

#### Three main ideas

- Uncertainty and stability
  - We see some regularities and stability in changeability. Can we understand some of them?
  - Can we estimate typical features using small samples?
    - If we saw a regularity, could we say that certain data observed conform to that (or reject such possibility)?
  - Statistical thinking and reasoning lead us to a new thought: we need a science to research regularities in random changeability. So, we need the probabilities theory

#### Three main ideas

- The probabilities theory as a math tool
  - We need the PT as a mathematical theory modelling randomness and changeability using few mathematically defined objects:
    - Events and probabilistic measure
    - Random values and their quantitative characteristics.
  - We go to the PT in grade 8th with intention to get back to statistics with newly developed instruments and views.

#### Three main ideas

- The top of the whole school stochastic is the LLN.
  Even if we don't know its mathematical reasons we have to understand the main principles: the LLN
  - provides stability in natural and social phenomena;
  - allows to measure unknown probabilities using frequencies;
  - allows us to forecast course of events leaning upon estimated probabilities





# Exemplary curriculum for HS. 2016 (fragment, basic and advanced)

- Conditional probability, full probability;
- Random values and distributions;
- Binomial distribution; geometric distribution
- Mathematical expectation and variance;
- ME and V of binomial and geometric distributions

# Exemplary curriculum for HS. 2016 (fragment, basic and advanced)

- Normal (descriptively) and exponential distributions;
- (Adv) Chebyshov's inequality and theorem; Bernuolly theorem; LLN
- (Adv) Joined distributions of two random values; independency and covariation;
- (Adv) Correlation; sample coefficient of correlation

#### Statistics for HJ school (main features)

- Combining calculations with decision rules, possible explanations; making likely conclusions;
- Moda is ruled out from learning;
- Developing a wide pool of problems for practical works using computer;
- Trying to work out 'qualitative statistical problems' rather than 'quantitative'
- Drawing information from graphs, charts, tables combined with texts, descriptions;
- Only real situations (no artificial or 'childish' subjects)

#### An example (7-8)

*Volga* is the main river of the European part of Russia. It starts in Tver Oblast and, describing a wide arc, flows to the Caspian sea. Many large industrial centers are located on Volga, as the river not only provides water that is necessary for all of us, but also works as a shipping way. The scheme shows some large cities located on Volga shores.



It is especially important to monitor a water level in spring. A water level in Russian rivers is measured in *meters of Baltic system* (mBS). The level of the Baltic sea in Kronstadt is taken as the zero level. Four graphs below show levels of water near four

cities: Nizhny Novgorod, Saratov, Cheboksary and Samara during the period 4-18 April 2018. The horizontal axis shows days of April, while the vertical axis shows the water levels in mBS.



#### Statistics for HS school (main features)

- Based on junior school: almost no new components;
- Avoiding purely technical problems. Emphasizing decision rules, assumption, possible explanations, posing hypotheses; drawing out information; estimating and comparing values from different sources;
- Requiring productive reading and comparing graphical data with text, technical descriptions etc.

#### An example (10)

The annual production of electricity is the total amount of electricity in Gigawatt-Hours  $(GW \cdot h)$ , produced at all power plants of a country for one year. The diagram shows the production of electricity in one large technologically advanced country for several years. The vertical axis indicates production in millions of gigawatt-hours. Data is rounded to the nearest hundredth.



#### An example (10)

4. *An annual production of wheat* is the total mass of all varieties of wheat grown in a country during one year. It is usually measured in million tons. *A yield of wheat* (in centners per hectare) is the ratio of the mass of wheat in centners to the total area of cultivated areas in hectares. The diagram below shows the production of wheat in million tons in four countries: France, Turkey, the United States and Australia for five years, starting 2002. Review the diagram and read the accompanying article.





Statistics is an art to derive reasonable and likely conclusions from small samples

Prof. Yuriy Tyurin

#### Thank you for your attention

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