



**TEACHING STUDENTS TO SOLVE PROBLEMS THEORY OF PROBABILITY AND  
MATHEMATICAL STATISTICS**

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### **Abstract**

Nowadays, probabilistic-statistical methods are now used in a wide range of disciplines, including physics, chemistry, pedagogy, psychology, linguistics, archeology, and geology, as well as probability theory in medicine and biology, military science and cosmonautics, linguistics, psychology, and teaching theory. Citizens have to overcome their deterministic thinking and recognize the existence of fundamental randomness in nature in order to perform effectively in society. Simultaneously, individuals should learn tactics and methods of reasoning that will assist in making appropriate judgments in everyday and professional circumstances involving risk. The importance of probability literacy has been acknowledged by educators in many nations by including teaching probability and mathematical statistics at various levels of education. The main purpose of this research is to build theoretical foundations for teaching probability and statistics in secondary school that are appropriate for their broad educational value, and to discover how to apply them in middle school mathematics classes.

*Keywords:* teaching probability and statistics, theoretical foundations, secondary school, mathematic classes

### *Introduction*

In the XXI century knowledge plays a significant role in education and art, technical progress where mankind has made great strides. The main requirement for education as a key factor in the modern development of the country is to provide quality educational services at the level of world standards. Since education is both a measure and a mechanism of civilization, the spiritual and social status of any state is assessed depending on the level of education.

One of the key issues in the development of the education system of the country is to improve the quality of education in line with the requirements of the times, education at the level of world standards. The main task of Kazakhstan to become one of the 50 most competitive countries in the world can be achieved only if highly specialized, skilled and educated people can easily master science and technology, self-govern in a market economy and apply their knowledge.

Indeed, the education system in the developed countries of the world is not a mechanical transfer of knowledge, but the ability to independently find, analyze and use information and intellectual resources, rapidly changing technological progress, self-disclosure in the face of



innovative growth, free to market demands. It is known that it gives priority to the formation of an adaptable personality. It is up to the family and the school to develop a well-rounded, creative individual who is able to work creatively and choose the path of self-education. The task of the family is to detect the child's talent at an early age, while the task of the school is to support the child and further discover and develop that talent. Especially at school the foundation of the student's own creativity is laid. That is why it is necessary to guide the student, to help him with his life plans and dreams at school. Such students should be involved in various creative works, research projects, participate in Olympiads and competitions. Mathematics also plays an important role in educating students as individuals.

There is no doubt that a comprehensive study of the content of mathematics at school and its appropriate application has a direct impact on the overall level of cultural development and knowledge of students. Problem solving in mathematics is the most important type of learning process. After all, by solving problems, the student learns mathematical theory and develops creative thinking with logical thinking.

The introduction of elements of probability theory and mathematical statistics into the current state compulsory standards of general secondary education of the Republic of Kazakhstan is the result of deep research by mathematicians, methodologists and teachers.

Elements of probability theory and mathematical statistics are selected according to age characteristics from elementary school. Collection and analysis of statistical data, their presentation in the form of various tables, charts and graphs, simple combinatorial calculations, finding the arithmetic mean, modes, medians of data were gradually introduced in the mathematical classes. These materials had a positive effect on the development of combinatorial thinking, the development of practical research activities, rather than mathematical abstraction. General educational updated curricula, including curricula for the subjects "Mathematics" for grades 5-6, "Algebra" and "Geometry" for grades 7-11, are correct.

In the 2017-2018 academic year, the 5th and 7th grades, in the 2018-2019, the 8th grades are taught according to the standard curriculum and curriculum of the updated educational content. The content differences of the updated or curricula are:

- \* the principle of helicity in the design of the content of the subject, that is, the gradual increase in knowledge and skills both vertically and horizontally (complication of skills by topic and by class);



- \* hierarchy of learning goals according to Bloom's taxonomy, based on the laws of cognition and classified according to the most important types of subject operations;
- \* pedagogical goal-setting according to the levels of education throughout the entire course of study, which allows or maximum to take into account intra-subject communications;
- \* the presence of "cross-cutting topics" between subjects both within one educational area and in the implementation of inter-subject communications;
- \* correspondence of the content of the sections and the proposed time requirements, with an emphasis on the formation of social skills;
- \* technologization of the educational process in the form of long-term, medium-term and short-term plans (Abylgazina, 2017).

Also, a distinctive feature of the new curricula is their focus on the formation of not only subject knowledge and skills, but also skills of a wide range. A built-in system of learning goals is the basis for the development of the following broad spectrum skills: functional and creative application of science, critical thinking, implementation of research work, using information and communication technologies, use of various ways of communication, the ability to work in a group and individually, problem solving and decision making. Thus, the flexibility and versatility of the updated curricula should be noted.

Teaching the course "Theory of Probability and Statistics" includes the organization of discussions in the classroom, intensive oral work, as well as expanding one's own horizons in the fields of other sciences, such as biology, geography, history, literature and many others, in addition to the established methods and learning approaches.

Approaches to the study of the elements of probability theory can be borrowed from the course of geometry, where, also, it is often necessary to solve several problems that are completely different from each other. At the same time, the tasks that stand side by side in the textbook are not similar, and the solution of one of the tasks does not mean that the next one will be easily solved. Therefore, the main condition for the growth of a teacher's professionalism in the field of teaching probability theory and mathematical statistics is a change in the technology of teaching activities in teaching this course.

#### *Materials and methods of research*

The question of modernizing mathematical education at school was raised in the early 1960s by the outstanding mathematicians B.V. Gnedenko (2001), I.I. Kikoin, A.N. Kolmogorov,



A.I. Markushevich, A.Ya. Khinchin. B.V. Gnedenko addresses a wide variety of readers, including mathematicians, teachers, and methodologists, because the topic of incorporating probabilistic-statistical information into school mathematics is long overdue and cannot be delayed any longer. The laws of strict determination, the study of which is entirely focused on school education, only one-sidedly reveal the essence of the surrounding world. The random nature of many phenomena of reality is beyond the attention of schoolchildren. As a result, their ideas about the nature of many natural and social processes are one-sided and inadequate to modern science. Gnedenko suggests that school children should be taught statistical rules that reveal the complex relationships between the existence of things and phenomena (Mansurova, 2014).

Levin claims that the statistical culture necessary for activity must be instilled from an early age. It is no coincidence that much attention is paid to this in developed countries. Students are introduced to elements of probability and statistics from their early days at school, learn probabilistic and statistical approaches to the analysis of general situations through education, and encounter life on a daily basis. (Kaiyngbayeva et al., 2018).

By the reform of the 1980s, elements of the theory of probability and statistics were included in the programs of specialized classes, particularly in physics, mathematics and natural sciences, as well as in the optional course in the study of mathematics. The process of introducing elements of probability theory and mathematical statistics into the compulsory course of school mathematics turned out to be a specific and difficult matter (Kaiyngbayeva et al., 2018).

There is a thesis that in order to assimilate the principles of probability theory, a preliminary stock of ideas and habits is needed that are fundamentally different from those that schoolchildren develop in traditional education. Therefore, according to a number of mathematicians, the stochastic line should enter school mathematics as an independent line that would ensure the formation, systematization and development of ideas about the stochastic nature of the phenomena of the world around us (Abramova, 2018).

Since the study of probability theory and mathematical statistics was recently introduced into the school curriculum, there are currently problems with the implementation of this material in school textbooks. Also, due to the specificity of this course, the amount of methodological literature is also still small. According to the approaches outlined in the vast majority of literature, it is believed that the main thing in the study of this topic should be the practical experience of students, so it is advisable to start training with questions in which it is required to find a solution



to the problem posed against the background of a real situation. In the learning process, one should not prove all the theorems, since a large amount of time is spent on this, while the task of the course is to form useful skills, and the ability to prove theorems does not apply to such skills.

One of the most important aspects of the modernization of the content of mathematical education is the inclusion of elements of statistics and probability theory in school curricula. This is due to the role played by probabilistic-statistical knowledge in the general education of a modern person. Without a minimum probabilistic-statistical literacy, it is difficult to adequately perceive social, political, economic information and make informed decisions based on it. The whole modern set of socio-economic sciences, such as physics, chemistry, biology, is based on the probabilistic-statistical base, and without proper preparation it is impossible to fully study it.

The elements of statistics are an integral part of the new content line of the school course of mathematics, which includes combinatorics and the basics of probability theory. The relevance of the study of statistics is due to the fact that statistical representations are the most important component of the intellectual baggage of a modern person. They are necessary both for everyday life in modern civilized society, and for the continuation of observance of human activity, for example, in human beings, such as sociology, economics, and medicine.

The course in probability theory and mathematical statistics is new to the modern school. The preparatory course of basic concepts at the intuitive, visual level is expected in grades 5-6, and in grades 7-9 - the construction, study and application of basic probability-statistical models. Thus, the first two stages of work on the concepts and methods of stochastics are defined. In 2003 It was decided to include elements of probability theory and statistics in the school mathematics course of secondary school. By this time, elements of probability theory and statistics had been present in fragmented form in well-known school textbooks of algebra for different classes and in the form of separate textbooks for more than ten years. However, the presentation of probabilistic and statistical material in them, as a rule, was not systematic, and teachers, more often than not, did not refer to these sections, did not include them in the curriculum. The document adopted by the Ministry of Education in 2003 provided for the gradual, phased inclusion of these sections in school courses, enabling the teaching community to prepare for the corresponding changes. In 2004–2008 A number of textbooks were published to complement existing algebra textbooks. Their authors are Abylkasymova A.E. and Shynybekov A.N. Teaching aids are also available to help teachers. For a number of years, all these teaching aids have been tested in schools. In



conditions when the transitional period of introduction into school curricula has ended and sections of statistics and probability theory have taken their place in the curricula of grades 7–11, it is necessary to analyze and comprehend the consistency of the main definitions and designations used in these textbooks. Note that all these textbooks were created in the absence of traditions of teaching these sections of mathematics at school. This absence voluntarily or involuntarily provoked their authors of textbooks to compare them with existing textbooks for universities.

From 2012 to 2016, the Ministry of Education of the Republic of Kazakhstan adopted new Republican textbook sets for various subjects. The content of a set of textbooks in mathematics for grades 8-11 is selected taking into account modern trends in the development of school mathematics education. These textbooks include a course in combinatorics, elements of statistics and probability theory. An important feature of the methodological apparatus is the underlying technology of level differentiation, which makes it possible to work in classes of different levels of mathematical training and individualize the learning process within this set.

These textbooks are compiled and written based on scientific facts and life experience of students. According to them, students learn to estimate the probability of random events at a qualitative level and perform quantitative calculations of probabilities, analyze statistics and use combinatorial formulas for calculations. These textbooks introduce a number of basic concepts of probability theory.

Random, reliable, impossible, more probable, less probable, unlikely, equally probable events are considered. New terms are associated with well-known words from life - often, rarely, always, never, "it is very possible", "it will happen", "it is unlikely", "it never happens" and others, which often determine the most common cases.

Textbook	Long-term plan	Contents of the long-term plan	Number of hours
7 algebra	Elements of statistics	Variation series. Absolute frequency and relative frequency. Frequency table. Frequency field.	6 hours (3 hours per week, total 102 hours)
8 algebra	Elements of statistics	Frequency field, frequency histogram. Average value. Dispersion. Standard	6 hours (3 hours per week, total 102)



		deviation.	hours)
9 algebra	Elements of combinatorics	Basic concepts and rules of combinatorics (rules of addition and multiplication). Solve problems using combinatorial formulas. Newton's binomial and its properties.	8 hours (3 hours per week, total 102 hours)
	Elements of probability theory	Fundamentals of probability theory. Output of text reports.	

Table 1. *Thematic planning of algebra lessons of 7-9 grades*

*Literature Review*

The studies of psychologists (J. Piaget, E. Fishbein) show that a person is initially poorly adapted to a probabilistic assessment, to the recognition and correct interpretation of probabilistic information. The works of psychologists claim that the age of 10-13 years is most favorable for the formation of probabilistic representations. Experimental work in grades 5 and 6 on propaedeutics of probabilistic representations, conducting experiments with random outcomes and discussing their results at a qualitative level showed that this period, not fixed by formal "mandatory results", gives a good development of probabilistic intuition and statistical representations of children (Gnedenko, 2001). Experience has shown that at the age of primary school, in a large number of ideas of the student in the world, there is not enough development, there is not enough mathematical apparatus (primarily simple fractions) to explain the ideas about probability. At the same time, the basics of descriptive statistics, tables and bar charts, may and even need to be introduced into the course of the national school. According to the data of scientists physiologists and psychologists, in the middle level of the school there is a noticeable drop in interest in the learning process in general and in mathematics in particular. At the math lesson in primary school, in the fifth and ninth grades, conducted according to the usual scheme and on traditional material, the student often feels an impenetrable wall between the objects being studied and the surrounding world. It is the probabilistic-statistical line, or, as it has recently been called, the stochastic line, the study of which is impossible without relying on the processes observed in



the surrounding world, on the real life experience of the child, that can contribute to the return of interest in the subject "mathematics" itself, the promotion of its significance and universality (Serikova, 2015).

In the CIS countries, the issue of introducing elements of statistics and the theory of probability into the content of mathematical education in general education classes is decided by such authors as E.A. Bunimovich, V.A. Bulychev, S.B. Suvorova, A.G. Mordkovich, P.V. Semenov, V.D. Celyutin, M.V. Tkacheva, N.E. Fedorov. In their dissertation dissected questions studied combinatorics in schools were interested in I. O. Belyaeva and E. P. Vinogradova. In the work of Belyaeva, combinatorial problems and the methodology for their study in middle classes were considered (Belyaeva, 1971). The work of Vinogradova is aimed only at primary classes. In his study "Stochastics at school as mathematics in the stages of creation and as a new class of mathematical and general education", A. Plotsky also considers depriving the content side of the belief-the statistical line in secondary school, without resorting to its methodology, is revived in specialized classes (Plotsky ,1992). Frantseva N.F. in the work "Development of methods for teaching elements of probability theory in grades 8 and 9 of secondary school" examines the features of teaching elements of probability theory and mathematical statistics as part of the mathematics course of secondary school. In their research, E.P. Mansurova and I.N. Sergeeva pay attention to the problem of continuity of studying probability theory and statistics at school and at university, identify the features of studying the topic at school and at university, and provide a comparative analysis of the content of these sections in school textbooks of various profiles. Also attached are schemes for introducing concepts, formulas, theorems on the topic, helping the teacher in reviewing the orientation in the material being studied (Mansurova, 2014).

In everyday life, we often have to deal with randomness, and the theory of probability teaches us to act rationally, taking into account the risk associated with making individual decisions. Familiarity at one level or another with the laws of the case is necessary for everyone. The application of the theory of probability in science, technology, economics and so on is gaining increasing importance. That is why, for more and more people in the process of work, there is a need to study the theory of probability. A modern educated person, regardless of profession and occupation, should be familiar with the simplest concepts of probability theory. Nowadays, when the weather forecast contains a message about the likelihood of rain for tomorrow, everyone should know what, in fact, this means. The main task in studying the elements of probability theory and



mathematical statistics is the education of the user, i.e. its formation of the ability to understand and interpret the statistical results presented, for example, in the media. What is needed is not so much a formal learning of new terms, but an initial acquaintance with the conceptual apparatus of this field of knowledge, an idea about which is necessary to every modern person.

The place and scope of the course of probability theory and mathematical statistics for children under 15 years of age vary in different countries, but the amount of material is significant in all countries and differs in some general basic elements taught in schools of all countries. In world practice, stochastic material is studied on an equal footing with numbers, functions, planimetry and stereometry throughout the entire course of primary, secondary and high school. In 1999, elements of probability theory and mathematical statistics were introduced into the practice of schools in Kazakhstan in the curriculum (project) of mathematics in secondary schools. The mandatory state standard of secondary education of the Republic of Kazakhstan, approved in 2002 and currently in force, defines the range of requirements for students on the elements of probability theory and mathematical statistics in the content of basic knowledge of the subject "Mathematics".

#### *Conclusion*

The idea of introducing elements of probability theory into the secondary school curriculum dates back to the ninth century. At the beginning of the XX century, advances in science and technology, molecular physics, necessitated the teaching of elements of probability theory in school.

In teaching probability theory and mathematical statistics, students help to connect with different fields, improve their knowledge, develop probability intuition, combinatorial thinking skills. Teaching the field of stochastics by sorting in each direction, implementing a professional-applied direction, promotes the formation of knowledge, skills, abilities of students, critical thinking of high school students, increasing their cognitive interest in mathematics in general.

#### **References**

1. Abylkasymova, A. E., Kucher, T. P., & Korchevsky, V. E. (2017). 7th grade Algebra Textbook. "Mektep" publishing house.
2. Abylkasymova, A. E., Bekboev, I., Abdiev, A., & Zhumagulova, Z. (2006). Algebra: Textbook for 9th grade of Secondary School. "Mektep" publishing house.



3. Abylgazina, A.E., & Tastanova, A.K. (2017). Updating the Content of Education is the Call of the Times. National Academy of Education named after Y. Altynsarin.
4. Abramova, E. A. (2018). Features of Studying Elements of Probability Theory in High School. *Collection of articles of the International Scientific and Practical Conference, Omega Science International Center of Innovation Research.*
5. Belyaeva, I.O. (1971). Combined Approach and its Application in the Application of Mathematics in the National School.
6. Gnedenko, B. V. (1965). On the Prospects of Mathematical Education. *Math at school.*
7. Gnedenko, B.V. (2001). Essay on the History of Probability Theory. *Editorial URSS*, 88.
8. Kaiyngbayeva, Z. B., Shuakaev, M., & Kossanov, B. (2018). The Importance Training of Statistics and the Probability Theory in the General Education School within the Framework of the Updated Education Content. *Journal of Educational Sciences*, 3(56), 71-79.
9. Mansurova, E.P. (2014). The Continuity of Teaching Mathematics at School and at the University on the Example of the Topic "Probability and Statistics". *Materials of the all-Russian scientific-practical conference*, 134-137.
10. Plotsky, A. (1992). Stochastics in the School as a Mathematician in the Field of Creation and as a New Element of Mathematics and General Education.
11. Serikova, V.S., & Dolgoplova, A. F. (2015). The Use of Sections of the Theory of Probability in the Analysis of Financial Markets. *International student scientific journal*, 3-4.