www.revistageintec.net
ISSN: 2237-0722
revista GEINTEC Gestão, Inovação e Tecnologias

Formation of Probability Physical Notions by Pupils on the Statistical Approach

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Abstract

The article offers suggestions for the introduction of probability-statistical ideas and concepts needed to improve the teaching of molecular and quantum physics departments in secondary schools.

Key-words: Statistical Method, Molecular Physics, Quantum Physics, Probability, Random Phenomena, Teaching Process, Pupil, Statistical Law, Atom, Molecule.

1. Introduction

All over the world, the quality associated with a logical, probabilistic-statistical, creative way of thinking, as an important criterion that determines the knowledge acquired by students in physics, is of great importance and requires research work based on an innovative approach in this area. This study is important in that it is aimed at the pedagogical and psychological solution of such tasks as increasing the activity of students, the development of a natural-scientific worldview, a statistical style of thinking, the formation of competence in a subject based on the statistical method, the active application of the knowledge and skills acquired in solving problems and performing laboratory work.

2. Main Part

Results and Discussions

In order to further increase the effectiveness of the reforms being carried out in Uzbekistan, create conditions for accelerated development, modernization of the state and implementation of

priority directions for the development of all spheres of society, including the education system, the Decree of the President of the Republic of Uzbekistan No.UP-4947 of February 7, 2017 on the Action Strategy was signed. In accordance with this decree, a separate paragraph introduced a radical improvement in the quality of general secondary education, including an in-depth study of such important disciplines as physics [1].

Table 1 - Comparison of the Educational Material of the Sections "Initial Information about the Structure of Matter" and "Thermal Phenomena" of the School Physics Course in Uzbekistan and the Russian Federation

Republic of Uzbekistan			**Russia**		
Class	Section	Study topics	Class	Section	Study topics
6	Initial information about the structure of matter	The doctrine of the structure of matter. Molecules and their sizes. Movement and interaction of molecules. Brownian motion. The phenomenon of diffusion in various media. Molecular structure of solids, gases and liquids.	7	Initial information about the structure of matter	The structure of matter. Molecules. Movement of molecules. Molecular speed and body temperature. Interaction of molecules. Three states of matter.
6	Initial information about thermal phenomena.	Heat sources. Heat receivers. Expansion of bodies when heated. Heat transfer in solids and liquids. Thermal conductivity. Convection. Radiation. The use of heat transfer in everyday life and technology. Temperature. Thermometers. Body temperature measurement. Laboratory work: Measuring the temperature of air and liquid using a thermometer.	8	Thermal phenomena	Thermal motion. Temperature. Internal energy. Ways to change the internal energy of the body. Thermal conductivity. Convection. Radiation. Features of various types of heat transfer. Examples of heat transfer in nature and technology. Quantity of heat. Units of the amount of heat. Specific heat. Calculation of the amount of heat required to heat a body or emitted by it during cooling. Fuel energy. Specific heat of combustion. The law of conservation and transformation of energy in mechanical and thermal processes. Aggregate states of matter. Melting and solidification of crystalline bodies. Melting and curing schedule. Specific heat of fusion. Evaporation. Energy absorption during liquid evaporation and its release during vapor condensation. Air humidity. Methods for determining air humidity. Work of steam and gas during expansion. Internal combustion engine. Steam turbine. Heat engine efficiency.

In general education schools of the Russian Federation, 374 hours are allocated for the study of physical and astronomical subjects in grades 7-11 [7, 8]. Table 1 is compiled comparison of the

materials of the above classes in the physics of the Russian Federation and Uzbekistan when studying the structure of matter and thermal phenomena.

In the countries of the Commonwealth, the problem of improving the teaching of physics was dealt with by G. Golin [1], G. Myakishev [6], A. Kikoin, I. Kikoin, S. Shamash, E. Evenchik [13], L. Tarasov [9], V.Orekhov, A. Usova, E.Mambetakunov and others [5], which describe the foundations of molecular physics and thermodynamics based on statistical ideas in textbooks and guides based on our own experience.

As you can see from these tables № 1, there are some inconsistencies in the study of certain topics. For example, the study of the speed of movement of molecules in the schools of Uzbekistan and Russia is studied only at a qualitative level. In our opinion, this is a significant drawback. To eliminate this deficiency, it is advisable to study this issue in full, for this there are all grounds and experimental facts, a specific example is diffusion in various media.

When studying the topic of thermal phenomena, it is advisable to use a statistical method that corresponds to the nature of the indicated phenomenon.

The table shows that in educational institutions of Uzbekistan and Russia, it is planned to have the same hours as the basic data structure. Topics of general lessons hours do not differ from each other [7,14]. However, these programs have no suggestions or recommendations for using the statistical method.

In this regard, in educational institutions, a number of works are being carried out to improve the study of teaching materials for teaching physics based on the following ideas:

- Transferring knowledge to students in the process of teaching physics to the proper degree, the formation of their skills and abilities that serve to obtain full-fledged knowledge;
- Forming the scientific outlook of students on the basis of teaching physics;
- Increasing students' interest in studying physics;
- Organization of a modern educational process, providing them with the opportunity for a lasting and perfect assimilation of educational material;
- Development of students' abilities for free, independent thinking;
- The formation of skills and abilities for students to apply the knowledge they have acquired in practice;
- Preparation of the foundation for the conscious professional orientation of students [10].

In the elementary grades, students acquire knowledge about certain physical phenomena (snow, rain, heating of the Earth by the Sun, freezing of water, etc., physical concepts (distance, area, volume, speed, time, etc.). Therefore, it is advisable to start with them explain the physics course of

the sixth grade by explaining the familiar phenomena with the use of elements of physical theory, which will further develop the students' ability to think and form in them scientific views in relation to nature [4].

The task of the teacher is to form in the minds of students a scientific and logical view of the concepts and patterns in each studied subject, correct from a scientific and logical point of view. Starting with the study of physics in the sixth grade as an academic discipline, the main task of the teacher is to explain in an abstract and logical sense the existing physical concepts in the minds of students, from simple to complex.

In the formation of physical knowledge, the following sources will be an assistant to the teacher:

- Life observations and experience of students;
- Knowledge learned in the assimilation of other disciplines;
- Teaching materials, textbooks, teaching aids and demonstrative experiments.

Under teaching materials in physics, a teacher should not understand only a discipline that studies physical quantities, their units and performs mathematical calculations. Physics is a discipline that studies natural phenomena, the mechanisms of their origin, the movement of bodies, the properties of substances and physical fields. An important task of teaching physics is considered, along with the transfer of physical knowledge to students, the expansion of their natural-scientific thinking.

Therefore, starting with the study of thermal phenomena in the sixth grade, it will be advisable to correctly explain to them the concept of the statistical method.

So, when transferring primary knowledge about the structure of matter, it should be emphasized that substances consist of microscopic particles - atoms, their movement is random. For example, the movement of snowflakes, flocks of insects can be compared to the movement of molecules and atoms. When modeling, it is possible to achieve the formation in the minds of students of a clear, full-fledged idea of the movement of atoms and molecules. The textbooks describe in detail the Brownian motion and the phenomenon of diffusion. However, if the students do not explain the laws of motion of atoms and molecules on the basis of the statistical method, incomplete and unconscious knowledge will be formed in their minds.

In order to eliminate these shortcomings, we consider it necessary to include in the educational process in the sixth grade the following concepts that have a statistical classification:

Table 2 - Some Concepts of Statistics Necessary for Studying the Structure of the Atom

№	**Statistical concept**	**Definition**
1.	The concept of probability	Expression, to a certain degree of accuracy, the occurrence of an event or phenomenon
2.	Random event	Events or phenomena that may or may not occur
3.	Inevitable event	An event or phenomenon, the occurrence of which is inevitable.
4.	Mean	The value obtained by repeatedly measuring the value of a certain physical quantity, adding these quantities and dividing the resulting sum by the number of measurements, that is: $n_{cp} = \frac{n_1 + n_2 + ... + n_m}{m}$.
5.	A mess	The state of the arrangement of particles or bodies without their subordination to any physical laws.
6.	Classical definition of probability	If the occurring massive random events are equiprobable, that is, their probability is evenly distributed, then the probability of its occurrence is $\mathrm{P} = \frac{n}{\mathrm{N}}$. In this expression, n – is the number of events of interest to us, and N –is the total number of tests performed

In high school, according to the program, students go through the following sections of physics, studied on the basis of the statistical method:

- Molecular physics and fundamentals of thermodynamics;
- Fundamentals of atomic and nuclear physics;
- Elements of quantum physics.

The basic ideas, principles, methods and results of molecular physics are of fundamental importance not only in physical science, but also of great scientific and methodological importance. Their main source is the real existence of molecules, their motion and interaction, the objectivity of the probabilistic and statistical laws concerning thermal motion, the difference between the thermal and mechanical motion of matter, and other concepts. When studying the psychological characteristics of students and the level of their knowledge in physics on the basis of probabilistic and statistical concepts of thermal phenomena, we come to the conclusion that it is necessary to be based on model experiments, to determine and limit their number. An analysis of textbooks, curricula and teaching aids in physics shows the availability of many materials on the use of probabilistic and statistical ideas and methods in the process of studying them. At the initial stages of a physics course, it is advisable to acquaint students with dynamic and statistical laws and their content.

According to R. Feynman, if as a result of some world catastrophe all the accumulated scientific knowledge would be destroyed and only one phrase would pass to future generations of

living beings, then which statement, composed of the least number of words, would bring the most information? *I believe that this is an atomic hypothesis (you can call it not a hypothesis, but a fact, but this does not change anything): all bodies consist of atoms - small bodies that are in continuous motion, attract at a short distance, but repel if one of them is tighter to press against the other. In this one phrase, as you will see, contains an incredible amount of information about the world, you just have to apply a little imagination and a little consideration to it* [12].

In the section of atomic physics, such very important issues as the discreteness of energy levels, absorption and emission of light by atoms, spectra and spectral analysis, and the principles of laser operation are studied. The discreteness of the energy levels in atoms is the basis for all other materials. The Rutherford-Bohr atomic model is the unification of Rutherford's atomic nucleus model with Bohr's quantum postulates. From the point of view of classical physics, such a combination is unnatural, since according to the laws of classical mechanics and electrodynamics, an electron located in the Coulomb field of an atomic nucleus can move along any trajectories and orbits, gaining and losing energy. Classical mechanics considers velocity (i.e. kinetic energy) and coordinate (i.e. potential energy) as continuously changing quantities. According to Bohr's postulates based on electron orbits, in the field of an atomic nucleus, an electron can move only along selected orbits and its energy discretely changes as a result of a transition from one orbit to another.

The mechanism of absorption and emission of light in atoms is explained as follows: after absorption of light, the atom passes into an energetically higher state, and after emission of light, into an energetically lower state.

In this case, the relationship between the frequency of the emitted and absorbed light and the energy of the atom is expressed by the formula

$$h\nu = E_n - E_m .$$

Such important questions as the probability of emission and absorption of light by atoms, the reasons leading to the emission of light, do not pass in the school physics course. The main reason for this is the undeveloped method of study and presentation.

In the methodological literature, energetic transitions during absorption and emission of light by atoms are considered in different ways: either on the basis of orbits (Rutherford-Bohr model) or on the basis of energy levels (quantum mechanics). In modern physics, they are presented on the basis of the energy levels of atoms. Firstly, this interpretation is general, and secondly, in reality, electronic orbits do not exist, the students know about this from the chemistry course. Therefore, we propose to use the concept of energy levels when explaining the interaction of light with atoms [3].

An explanation of the wave nature of micro-objects, the uncertainty and stability of atoms arising on this basis, relying on probabilistic laws, serves to form students' modern ideas about the atom. Taking into account the above disadvantages, it is advisable to introduce the following statistical concepts into the educational process.

Table 3 - Some Statistical Concepts Needed to Explain the Atomic Hypothesis

№	**Statistical concept**	**Definition**
1.	Statistical method	The statistical method is used to check and study common phenomena, that is, a large set of simple, individual, similar to each other and (at least to a certain extent) independent from each other.
2.	Statistical regularity	The pattern that systems that consist of many particles obey.
3.	Statistical determination of probability	A statistical definition of the probability of the occurrence of events that do not have equal probability is given, that is, $\mathrm{P} = \lim_{N\to\infty}\left(\frac{n_i}{\mathrm{N}}\right)$
4.	Geometric definition of probability	The probability is equal to the ratio $\mathrm{P} = \frac{\Delta V}{V}$, this expression reflects the geometric definition of probability. If the condition is met $\Delta V = V$, the probability value is equal to one, this is $\mathrm{P} = \frac{\Delta V}{\Delta V} = 1$, because a particle at an arbitrary moment of time will necessarily meet in some place of the volume V, hence, due to the inevitability of the occurrence of an event, its probability is equal to $P = 1$, that is, the probability turns into reality.
5.	Microstate	A state characterized by the location of all molecules forming a system at an arbitrary moment in time.
6.	Macrostate	Macro state is a state of a body that corresponds to an equilibrium state and is characterized by thermodynamic parameters. Molecules move chaotically, in this case there are many microstates corresponding to one macrostate.
7.	The concept of chaos (disorder)	Thermal (disordered) movement in gases is a change in the direction of movement of a molecule from one collision to another.
8.	Statistical system	A statistical system is understood as a system consisting of randomly moving particles and being in an equilibrium state (constant pressure, temperature, volume).
9.	Thermodynamic equilibrium	Time invariability of parameters (P, V, T) expressing the state of the system.

3. Conclusion

If the statistical method is used in teaching molecular and quantum physics in secondary schools, students will clearly represent the application of the above probabilistic and statistical ideas and concepts, therefore they will acquire full knowledge of these sections.

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