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The Importance of Types of Scientific Knowledge in the Development of Students' Creativity

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Abstract

In the article, the formation of types of scientific cognition, especially epistemic cognition among students is considered as an example of problems related to the analysis of the movement of a point charge in the electric field of uniformly charged bodies of finite size.

In addition, integration was used to calculate the electric field strength of charged bodies, and by integrating it over different intervals, it was shown to obtain information about the trajectory of the field force lines consisting of broken lines and, accordingly, the trajectory of the point charge. It is proposed that the solving of these types of problems helps students to acquire epistemic knowledge and develop creativity by applying it.

Keywords: Scientific cognition, methodological and epistemic cognition, point charge, electric field lines, electric field strength, Barycentric coordinates, electrostatic potential.

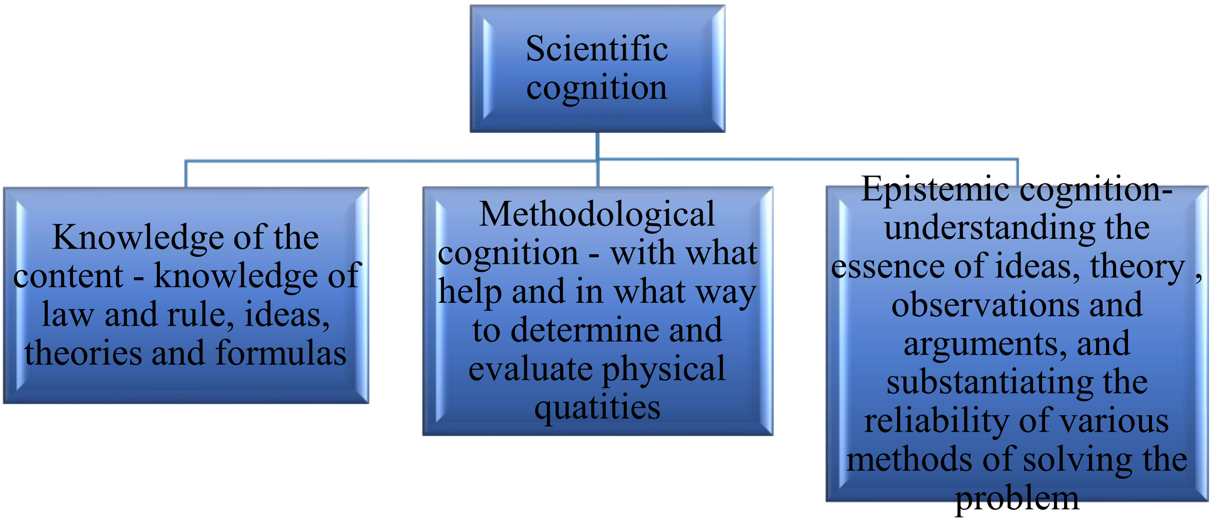
1. Introduction

In the context of globalization, the rapid development of science and technology, occupying the main place in social life poses wide-ranging but urgent problems to the state and society. In order to get a place among the developed countries, not lagging behind the international community, the country has a special place of high-potential engineers in the field of educated, experienced and modern-minded Physics, Mathematics, Chemistry and biology. About this, the president of the Republic of Uzbekistan noted that: "The success of the reforms carried out in our country, the worthy place of our country among the developed, modern countries of the world is inextricably linked, first of all, with the development of the field of Science and education, in this regard, with our ability to be competitive on a global scale" [1].

In the training of specialists who meet these requirements, it is necessary to introduce new concepts of education and assessment of students in general Secondary Education, which is the main link of education, into the educational system of our Republic. According to the analysis of the foreign experience, in modern education, a special emphasis is placed on the development of critical thinking, creativity, skills and competencies of independent search for information and its analysis. In addition, according to the concept of modern education, a new system of assessing the skills of students to be able to apply the knowledge and skills acquired in school to life situations, their attitude and motivation to education, to be able to understand the problem and pay for it, namely, the International Assessment Program PISA, was developed [2]. The PISA international assessment program mainly evaluates student literacy in reading, mathematics and natural sciences. Since physics is part of the Natural Sciences Complex, it also requires basic attention, and the competency requirements for the natural sciences are also relevant to physical education. So, in physics education, pupils must have formed the following three competencies according to the requirements of PISA.

1. Being able to scientifically explain physical phenomena and see the problem in it
2. Design scientific research to solve a physical problem and scientifically assess the optimal solution
3. Scientific interpretation of the data and evidence used in solving the problem. Scientific justification of the use of the solution of the problem in solving a second problem.

All three of the above competencies are based on science, and therefore it is necessary to focus on scientific knowledge in the educational process. Scientific cognition consists of the following types of cognition, which are inextricably linked and continue without interruption.



In education focused primarily on knowledge-giving, little emphasis is placed on epistemic knowledge-giving. In practical classes in physics, the focus is on strengthening the acquired knowledge of the content of science, while in practical lessons, methodological knowledge is focused. From the modern concept of education, it is necessary to expand the goal for practical and lab training, that is, together with the strengthening of new knowledge acquired in the course of the lesson, we need to teach students to acquire methodological knowledge in a broad sense and apply epistemic knowledge.

In secondary and physical and mathematical specialized schools in our Republic, at the moment, questions ranging about medium complexity from physics are mainly used in practical lessons. The questions used in secondary schools are mainly taken from the "collection of problems from Physics" published under the name of A.P.Rimkevich [3], in specialized groups, questions are taken from "Topic questions from Physics" categorized by various authors as the supplementary source to the above book [4]. Therefore, working on these problems consists of finding its answer, which requires almost no analysis, and it does not give epistemic knowledge to students at all.

2. Problem statement and its discussion

Let's see the formation of epistemic knowledge in students using the example of working on issues related to the electric field. It is known that in matters concerning the electric field voltage and potential intended for use in practical training in physics, it is required to determine the voltage and potential of the electric field that has formed mainly the point charge, charged sphere, conducting sphere, infinite plane and straight line. With the help of such issues, epistemic knowledge is mainly formed in determining the field potential, since to some extent in readers we can cite the following as an answer to the question of why we determine the potential:

Knowing the potential of this point the charge and mass of an object located at this point is known, we can find the work done by the speed or field that it achieves when moving to some distance, but information about the trajectory of movement of a charged particle cannot be taken.

The charged particle motion trajectory is oriented along the lines of force, so field lines of force are known to have central axis symmetry or charge an infinite plane. But since the field of some charged objects of finite size is not symmetric, we will not have full knowledge of the motion of the charged particle. The main problem here arises in determining the appearance of the trajectory of motion of charged particles. It is known that the trajectory of a moving object is in the direction of the resultant force. If the direction of the resultant force acting on an object changes from point to point, the trajectory of motion will consist of a curve. With a force acting on a particle moving in an electric field, the electric field intensity vector is mutually collinear. Namely:

$$\vec{F} = q\vec{E}$$

Depending on the sign of the charge, $\vec{F} \upuparrows \vec{E}$ or $\vec{F} \uparrow\downarrow \vec{E}$ is observed. The legitimate question arises here, that is, what is the problem? A problem solution would be easy if the electric field were centrally symmetric or symmetric with respect to the axis. Because the trajectory overlaps with the radial vector directed along the lines of electric field intensity, but if it consists of a plane and a cross-section of charged finite size or their different configurations, it is more complicated to determine the trajectory. Therefore, in school educational problems, it is mainly required to determine the value of the electric field strength at only one point lying on a line passing through the center of the charged disc or at some distance from the finite cross-section. Such a setting of the problem does not lead to the formation of epistemic knowledge in students, but methodological knowledge is formed, because the question of why we find the field is strengthened and what information we can get from it is not asked in the problem.

It would be expedient to set the problem of determining the movement trajectory of a charged particle for the formation of epistemic cognition in students with the help of these types of problems.

We consider the formation of epistemic knowledge in students by working on problems related to the electrostatic field and the movement of charges in this field in the physics-mathematics specialized schools and practical lessons in Presidential schools in the upper classes.

As we mentioned above, it is somewhat difficult to find the value of the electric field intensity vector or potential value of charged bodies with finite dimensions, since the lines of electric field force are not symmetrical about the center and the axis.

Issues related to this direction are covered in detail in several articles, including [5] where the electric field potential of a plane-charged triangle is found in barycentric coordinates, but the disadvantage of this method is that the field strength does not provide an opportunity to successively find the direction of the vector. Because the asymptotic character of the obtained analytical expression for the field potential is studied only in special limits that satisfy certain values, and numerical results are obtained, but it is not possible to obtain information about the appearance of electric field lines of force based on determining the direction. Several other studies have been conducted on the calculation of the electric field potential of flat-charged bodies of different shapes and their application to education, but they were also limited to finding values for specific points [6,7].

By determining the electric field lines formed around charged objects of finite size, we use the method from simple to complex, ensuring coherence in the formation of epistemic knowledge in students, following didactic principles. For this, we will first consider the following problem.

Problem: If a point charge with charge q is released from a dielectric rod of length L charged with a uniform charge density from a point A that does not lie on it, what trajectory will it move along?

Taking this problem as a qualitative problem, the students tried to justify it by accepting two different trajectories as solutions.

1. A point charge moves away from a rod of length L in a direction perpendicular to it (Fig. 1). As a basis for this, the electric field lines of an infinitely charged thread are perpendicular to the thread symmetrically, in all directions.

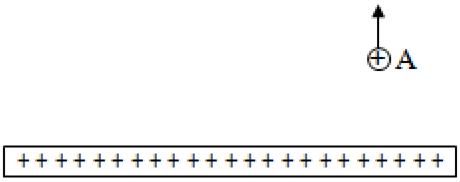


Fig. 1

2. Assuming that a point charge moves along a straight line drawn from the center of a rod of length L to the point where the charge is located (Fig. 2), as a basis, when determining the gravitational force of attraction between objects, the distance between the objects is their center of gravity will be the distance between and the force will overlap with this radius vector.

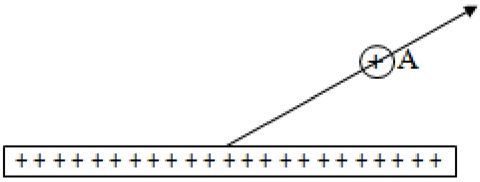


Fig. 2

If we consider this issue as a small educational research, we must explain that the students could not scientifically interpret their previous knowledge and data for the general case, but only in the following special cases. That is:

1. If a point charge lies at an arbitrary point of a straight line perpendicular to the center of a rod of length L (for idea 1).
2. Until the relation $a \ll L$ is fulfilled between the distance from the point charge to the straight line a and the distance L between the straight line.
3. If the point charge lies at an arbitrary point along the length of the rod L.

If we do not describe both ideas as above, it will be completely wrong and we will not be able to use it later, because we emphasize that we will use the argument given to support idea 2 in particular to solve the problem.

We emphasize that in working out the problem we will use the scientific evidence given to justify the second idea, that is, the distance between the "centers of gravity" in finding the interaction between bodies, but for this we will use the stern with a small Δl ($\Delta l \ll L$) into pieces and note that we use the distance and vector between these pieces and the point charge (Fig. 3).

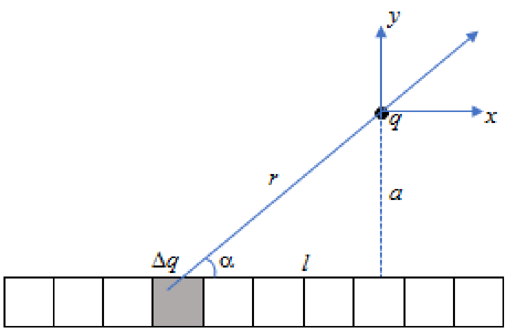


Fig. 3

In this case, we use Coulomb's law, because since $\Delta l \ll L$ we can also consider the particle Δl as a point charge. Therefore:

$$\Delta F_i = k\frac{q\,\Delta q_i}{r_i^2}$$

or since the total force equals $\vec{F} = \sum \Delta F_i = qE$ it yields $\vec{E} = \sum \Delta E_i = k\sum \frac{\Delta q_i}{r_i^3}\vec{r_i}$. Using the expression, we can find the value of the field strength vector.

We write the above expression in the form of an integral, taking into account that students in the Department of Physics and Mathematics are familiar with the integral.

Considering that $\Delta q \rightarrow dq = \tau dl, l = actg\alpha \ \rightarrow \ dl = a\frac{1}{sin^2\alpha}\,d\alpha,$

$r = \sqrt{a^2 + l^2}$, we can have $E = \int \frac{\tau dl}{a^2 + l^2}$. While calculating this integral, considering that the electric field strength is a vector quantity, it should be noted that it is necessary to first find the components of E in the x and y axes, and then find $E = \sqrt{E_x^2 + E_y^2}$. Where $dE_x = dEcos\alpha$ and $dE_y = dEsin\alpha$ or $E_x = k\tau\int\frac{ldl}{(a^2+l^2)^{3/2}}$ and $E_y = k\tau\int\frac{adl}{(a^2+l^2)^{3/2}}$; $(\cos\alpha = \frac{l}{r} = \frac{l}{a^2+l^2}$ and $\sin\alpha = \frac{a}{r} = \frac{a}{a^2+l^2})$

It should be noted to the students that the components E_x and E_y are primary importance in finding the trajectory of a free point charge, i.e. lines of electric field strength. Because in a small-time interval, a charged particle starts moving from point A to the x-axis and changes its coordinate from (x_A, y_A) to $(x_A + \Delta x, y_A + \Delta y)$ coordinate in a small-time interval Δt. Here, $\tan(\alpha)$ can be determined from the relationship $tana = \frac{\Delta E_y}{E_x}$ to find the relationship between Δx and Δy gains through the relation of $\Delta y = \Delta x\ tg\alpha$. In that case, we calculate the next positions of the points where the point charge is based on the condition of the problem as $(x_A + n\Delta x, a + \sum_{i=1}^{n}\Delta\, x_i tg\alpha_i)$. Taking this into account, by integrating the above integral over different intervals, we get a motion trajectory consisting of broken lines or a line of field strength in the form of a broken curved line (Fig. 4).

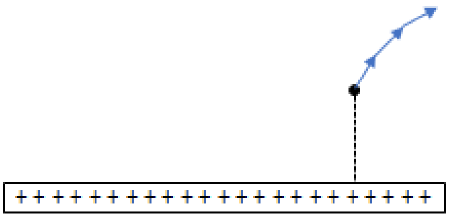


Fig. 4

If we calculate the integral using computer numerical modeling, our possibilities expand even further and we can describe the appearance of field lines of force on a charged rod of finite length (Fig. 5).

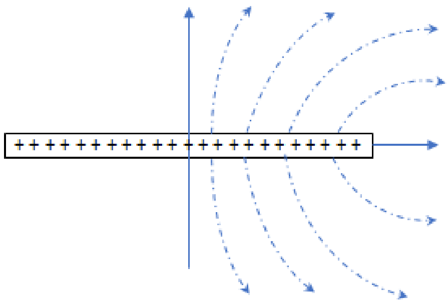


Fig. 5

By complicating the problem a little, that is, by using the above integration based on the principle of simple to complex, it is possible to find the value of the field strength and the trajectory of the field lines at arbitrary points lying in the plane of the triangle charged with the same linear charge density τ on sides *a*, *b*, *c* (Fig. 6).

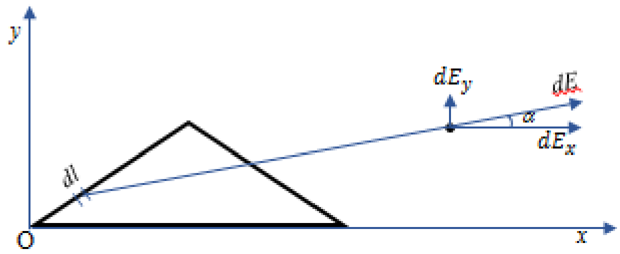


Fig. 6

Using numerical modeling, teachers and students can also see how the distribution of field lines changes by changing the linear charge density of one side of the triangle.

Summary

In the educational process, by using problems such as describing electric field lines of force produced by uniformly charged bodies of finite size, students will achieve the following:

1. They will be able to imagine the existence of a difference between the electric field lines of uniformly charged bodies of finite and infinite sizes.
2. They will understand that the formulae derived for the vector of electric field strength of point charges and infinite sized objects can be used individually or in some interval to calculate the electric field strength of a charged body of finite size.
3. They will realize that the formula and principle of superposition for the field strength vector of a point charge are one of the main methods for calculating the value of the electric field strength vector of charged objects with different shapes and sizes.
4. Most importantly, they will understand that it is possible to solve the problem of determining the magnitude and direction of the force acting on the charge located in the field by the value and direction of the electric field strength vector, as well as determining the appearance of the field lines and the trajectory of the motion of a charged particle. This is the answer to the question of why we learn the electric field strength and it has a great importance in the formation of students' epistemic knowledge.

By finding the electric field lines formed by uniformly charged bodies of finite size, it is possible to develop students' divergent thinking skills, creativity and critical thinking, together with the formation of epistemic cognition. In addition, the use of various numerical modeling methods in the description of field lines enriches methodological cognition.

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