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An Alternative to Provide Meaningful Learning in Teaching Physics in High School

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Abstract: ***This work presents a methodological alternative for teaching Physics in basic education. Due to the ineffective methods of teaching Physics in traditional schools and the mythification surrounding this subject, new teaching methodologies based on the concepts of meaningful learning in which the individual characteristics of students are valued. This initiative aims to reduce student abandonment and rejection of the physics subject.***

Keywords: Methodology, traditional schools, physics teaching, problems, meaningful learning

1. Introduction

It is quite common for students to drop out due to the high rate of failure and lack of interest in physics subjects in high school. This has worried academic teachers and researchers who address the problem of Physics teaching in Brazil (Anjos, 2023).

There has been much discussion about how to improve the teaching and learning of Physics in high school. Much of this problem exists due to the way teachers still teach. Many are still based on the teaching methodology of traditional schools in which the teacher robotically goes over the material in the books. This makes learning mechanical and repetitive, going against the most contemporary theories about meaningful learning (Sousa, 2023).

According to Comiotto, 2011:

> "The Traditional School, focused only on pre-established content and governed by a rigid curricular structure, prioritizing the quantity of learning as the final product; presenting authoritarian teachers and students receiving diverse knowledge, it does not adapt to current perspectives."

Based on this analysis, it is reasonable to suggest that measures be taken to modify this paradigm of current teaching practice. It is necessary to update teaching methods. Still according to Comiotto, 2011, the new school model requires an education based on Man, where the idea of "learning to learn" is a priority. In this conception, there is an appreciation of the individual characteristics of the student.

Teaching in general has lost its terminal character. This characteristic manifests itself even more in higher education. Currently, the proposal for continued learning opens up a panorama that education has no end, that it is a process that is built moment by moment; it proposes that students and educators be creative, innovative and always motivated to search for new information and skills.

Still according to Marco Antônio Moreira, "meaningful learning is a process through which new information is related, in a substantive (non-literal) and non-arbitrary way, to a relevant aspect of the individual's knowledge structure". In other words, the new knowledge that is acquired is related to the previous knowledge that the student has.

In contrast to meaningful learning, at the other end of a continuum, is rote learning, in which new information is memorized in an arbitrary, literal, non-meaningful way. This type of learning, highly encouraged at school, is used to "pass" assessments, but has little retention, does not require understanding and does not cope with new situations. We also know that meaningful learning is progressive, that is, meanings are progressively captured and internalized and in this process language and personal interaction are very important. (Silva Neto, 2023).

Ausubel (1982) proposes these two programmatic principles of the teaching subject as a natural consequence of corresponding to two processes in the dynamics of the cognitive structure. In other words, in search of cognitive organization, the person who learns is, at the same time, progressively differentiating and integratively reconciling the 6 acquired knowledge. Consequently, teaching will be more facilitating of meaningful learning if it considers processes as organizing principles.

This work presents a suggested work plan for a high school class. This plan consists of: a directed study work (DE) with the Physics teacher together with the monitors. The other aspect consists of intensifying monitoring activities. In addition to the introduction, this article is divided into:

Purpose: this section presents the purposes of the article;
Theoretical Reference: consists of a concise and quick explanation of the topic explored;
Methodology: presents how the work was planned and programmed;
Conclusion: proposes the final analysis of the work to achieve the desired results;
Bibliographic references: presents the references cited throughout the work.

2. Purpose

The main purpose is to present and analyze the work strategy to be implemented in a high school group in the Physics discipline with the aim of guaranteeing meaningful learning for students.

In general, Physics content is divided into three main areas. They are:
1) Classical Mechanics;
2) Thermodynamics, Waves and Optics;
3) Electromagnetism and Modern Physics

Initially, you can direct the work to the most difficult area or carry it out as a whole. This depends on the time the teacher has at his or her disposal. In this article, the mechanics will be chosen to simplify the planning analysis

The following sections provide a brief description of the subtopics covered.

3. Theoretical Reference: Classical Mechanics

3.1 Kinematics and vectors

Kinematics is the branch of physics that deals with describing the movements of bodies, without worrying about the analysis of their causes (Dynamics). Generally we work here with material particles or points, bodies in which all their points move in the same way (same speed, with the same orientation) and in which their dimensions are ignored in relation to the problem. Kinematics can address scalar quantities or vector quantities. The difference between these two types of magnitude is described below.

Some quantities are perfectly defined with a numerical value and its unit of measurement. This is the case, for example, of temperature. When it is said that the ambient temperature is 23º C, no further information is needed to explain this phenomenon. However, there are quantities that, in addition to the numerical value and the unit of measurement, require a direction and meaning so that they can be perfectly defined. For example, the distance between Goiânia (GO) and Brasília (DF) is approximately 170 km. To get to Brasília, starting from Goiânia, you must travel approximately 170 km, in a northeast direction towards Goiânia-Brasília. Figure 1 shows the relationship between the space covered by a particle, ΔS, and the time, Δt, taken to travel through it. This figure translates the concept of average speed.

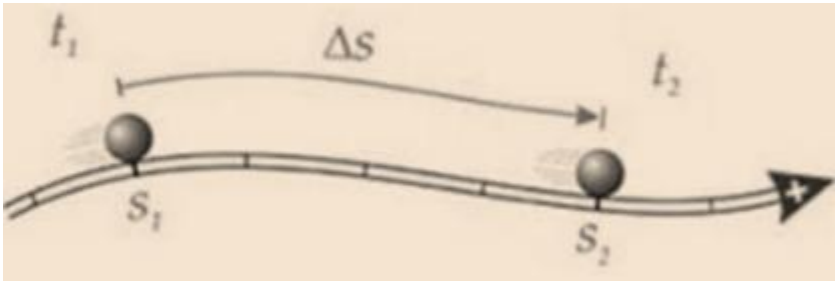

Figure 1: Illustration of the concepts of space and time of a particle

3.2 Dynamics and Energy

In the field of physics, dynamics is the science that studies movement, considering only forces as its causes. It is one of the best-founded chapters in physics and provides the clearest and most intuitive results when applied to rigid bodies.

Dynamics is based on Newton's laws, but with a much more complex mathematical treatment. Dynamics is also responsible for studying the movement of gases (aerodynamics) or liquids (hydrodynamics). In general, a certain empirical point of view, based on experimental data, predominates in this science.

In the part related to energy, the laws of physics that govern the basic principle of conservation of energy are basically studied. The law or principle of conservation of energy states that the total amount of energy in an isolated system remains constant. This principle is closely linked to the definition of energy itself. An informal way of stating this law is to say that energy can neither be created nor destroyed: energy can only transform.

The figure 2 below illustrates a classic phenomenon of energy conservation.

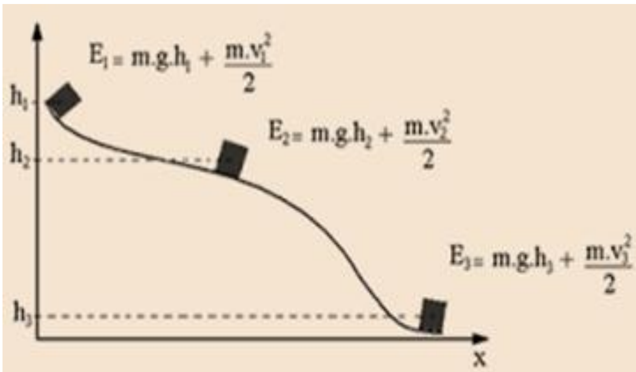

Figure 2: Launching a block around a surface with a non-regular trajectory

3.3 Rotational dynamics

Rotational dynamics is a part of dynamics that addresses the application of Newton's laws to the rotation of rigid bodies. Dynamics is first studied, using Newton's equations, for translational movements. After understanding these laws in translation, focus is given to the study of rotation.

It is essential that when analyzing Newton's laws for rotation, the student learns the concepts of torque and moment of inertia:

Moment of inertia (I): according to Silva, 2017, it is possible to infer that the moment of inertia, or moment of mass inertia, expresses the degree of difficulty in changing the state of motion of a rotating body. Unlike inertial mass (which is a scalar), the moment of inertia or Tensor of Inertia also depends on the distribution of mass around an arbitrarily chosen axis of rotation. The greater the moment of inertia of a body, the more difficult it is to make it rotate or change its rotation. The portion of mass that is far from the axis of rotation contributes most to the increase in the value of the moment of inertia. A thin and long rotating axis, with the same mass as a disk that rotates relative to its center, will have a moment of inertia smaller than this. Its unit of measurement, in SI, is kilogram times meter squared (kg·m²). In classical mechanics, moment of inertia can also be called rotational inertia, polar moment of inertia. The dimensional analysis is shown in equations 1 and 2.

$$[I] = [m].[d^2] \tag{1}$$
$$[I] = kg.m^2 \tag{2}$$

Torque (T): as explained in Silva, 2017, torque, lever moment or simply moment (the latter term should be avoided, as it can also refer to angular momentum, linear momentum or moment of inertia) , is a vector quantity in physics. It is defined from the component perpendicular to the axis of rotation of the force applied to an object that is effectively used to make it rotate around an axis or central point known as a pivot point or point of rotation The distance from the pivot point to the point where a force 'F' acts is called the moment arm and is denoted by 'r'. Note that this distance 'r' is also a vector, as shown in figure 3. Follow the dimensional analysis shown in equations 3 and 4

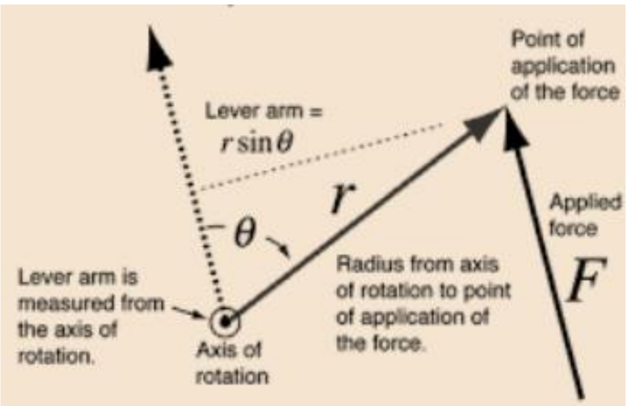

Figure 3: Representation of the torque of a force

$$[T] = [F].[r].[sen\theta] \tag{3}$$
$$[T] = N.m \tag{4}$$

4. Methodology

The plan must focus on two fields of action: directed study and individual guidance. In both, integration between teacher and monitor is important. Table 1 shows both fields.

Table 1: Planning methodology illustration

Methodology	Directed Study (DE)
	Individual guidance (IG)

In the Directed Study (DE) activity, a list of 3 to 4 questions can be proposed weekly, which address both conceptual and calculation problems, and which must be solved by students in groups of 5 members under the guidance of the monitor. Directed study should be applied at different times for two halves of the class, or the division of the class that is most convenient. The class division aims to improve the quality of student/monitor interaction and vice versa. Furthermore, the timing of these activities must be appropriate for the type of issues addressed.

Individual guidance: in the study room, the student can ask for clarification about the content or propose questions to be discussed with the monitor and/or with the students as well. Individual guidance can also occur twice a week. In these meetings, the approach aims to show a practical view of the concepts seen in the classroom, as well as in guided study.

In both meetings, DE and IG, the presence of students must be registered. This is necessary to make a comparison between the performances of students who attend activities versus those who missed the activities.Student analysis can be done by comparing the average grades, $\bar{x}$,central tendency statistic, of students who participated in studies against those who did not.A statistical analysis using dispersion measures such as standard deviation, σ,is also useful to assess how far students are from the averageThese statistical measures are shown in equations 5 and 6 (Pinheiro, 2021).

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \tag{5}$$

$$\sigma = \left(\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})\right)^{0.5} \tag{6}$$

Where x_i represents a student's grade and n the total number of students.

5. Conclusion

As this is planning work, the conclusions are only expected hypothetical conditions. It is expected that students who attended (directed study and individual guidance) had much better averages than those who did not attend the activity.

In this context of class work planning, monitoring must look for alternatives to ensure that the student retains the content in order to guarantee more meaningful learning.During this period, efforts should be made to incorporate more study concepts into the class' daily knowledge in order to establish better relationships between the subjects covered and the students.

Finally, it is expected that this teaching methodological alternative will make the physics subject for high school

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more attractive, allowing the student to demystify the subject which naturally faces a term.

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