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PROPOSAL FOR A POTENTIALLY SIGNIFICANT TEACHING UNIT (UEPS) FOR TEACHING MODERN PHYSICS TO HIGH SCHOOL STUDENTS: THE CORPUSCULAR NATURE OF LIGHT AND ITS APPLICATIONS

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Abstract: The search for new strategies that assist in the teaching-learning process of modern physics in basic education in the country is necessary, above all, to develop contextualized, non-fragmented and meaningful learning of what is taught in the classroom. It is in this direction that this article discusses the issue of meaningful learning and potentially significant teaching units (UEPS) focusing on the teaching of modern physics: the corpuscular nature of light, in high school. To achieve this, the discussion is based on significant and critical learning from authors such as David Ausubel and Marco Antônio Moreira. In the end, it is reflected that the application of UEPS is a teaching-learning strategy that can contribute to the application of modern physics concepts relating to technological advances and also to students' everyday situations.
Keywords: meaningful learning, modern physics, education.

INTRODUCTION

The dominant model in the teaching-learning process in schools in Brazil is still based on the active participation of the teacher who passes on the content of his subject to the students, according to the guidelines of the textbooks. This teaching-learning model involves only one transfer, the conceptual content, without taking into consideration, the interactions between previous knowledge and new knowledge. In many cases, it does not guarantee the effectiveness of learning and turns classes into a mechanical process and, consequently, generates a lack of interest in the subject among some students.

It is in light of this scenario that the Ministry of Education (MEC), over the last 30 years, has incorporated into its legislation and guidelines for schools, proposals that aim to transform the teaching and learning process. An example of this can be seen in the National Curricular Plans (PCNs) and the National Curricular Bank (BNCC), in which the directions for the area of Exact and Natural Sciences point to the need to use, in the school context, activities that involve the search information from different sources. These activities allow us to go beyond obtaining information to elaboration/re-elaboration of ideas and attitudes, promoting "the development of autonomy in relation to obtaining knowledge" (BRAZIL, 2023). Just as Moreira (2000) understands that the dominant and traditional form of teaching based on expository classes and the elaboration of exercises and their resolutions needs to be overcome.

In this sense, the objective of this work is to discuss critical meaningful learning in teaching-learning, focusing on the teaching of modern and contemporary physics, with a focus on the corpuscular nature of light, which is one of the contents of high school students. To this end, the theoretical foundation of this discussion is based on Critical Meaningful Learning treated by David Ausubel and Marco Antônio Moreira.

To better understand this discussion, this article is structured into three sections. In addition to this introduction, the following section, the theoretical framework, is divided into two subsections, which initially points out the concepts of meaningful learning and its implications for the teaching and learning process, and the following subsection presents the significant potential teaching units (UEPS) heading towards the field of modern physics with a focus on the corpuscular nature of light and the conclusions that conclude it in the third section.

THEORETICAL REFERENCE

CRITICAL MEANINGFUL LEARNING: ITS CONTRIBUTIONS TO TEACHING AND LEARNING

For Moreira (2000), teaching and learning in Brazilian schools are still based on a traditional and mechanical model. This model is based on rigid structures regarding content, use of pre-defined teaching materials and resources, as well as the role of the teacher becoming central so that the class can be carried out, with students' prior knowledge being little taken into consideration, within of this process.

Thus, Moreira (2012) himself defends the concept of meaningful learning, as consisting of symbolically expressed ideas which interact in a substantive and non-arbitrary way with what the student already knows. This in a substantive, non-literal, non-literal and non-arbitrary way.

In this sense, Moreira (2012) reiterates that meaningful learning is characterized by the interaction between prior knowledge and new knowledge and that this interaction is non-literal and non-arbitrary. Thus, new knowledge acquires meaning for the subject and previous knowledge acquires new meanings or greater cognitive stability.

It must be noted that the concept elaborated by Moreira (2000;2012) is based on the studies of the North American psychologist David Ausubel, who, in the 1960s, pointed out that learning is based on what the individual has, specific knowledge or what exists in its structure.

Ausubel (2003) starts from the premise that individuals have an internal cognitive organization based on conceptual knowledge, in which its complexity depends much more on the relationships that these concepts establish within themselves. These relationships have a hierarchical character, so that the cognitive structure is understood as a network of concepts organized in a hierarchical way, according to the degree of abstraction and generalization.

Based on this premise, Moreira (2000, 2012) believes that for meaningful learning to occur, some conditions are necessary and points out two main conditions:

The first is about learning material that must be potentially meaningful, which implies learning material such as: books, classes, applications, that have logical meanings (are relatable in a non-arbitrary and non-literal way to a cognitive structure appropriate and relevant).

However, it is important to emphasize that there is no meaningful book or meaningful class, but that both material and class can only be potentially meaningful if linked to people and not to the materials themselves. For Moreira (2012), it is the student who attributes meanings to classes and materials presented in the classroom based on their cognitive capacity and prior knowledge.

In the second, the student must present a predisposition to learn. To do this, it is necessary that it has relevant anchor ideas in its cognitive structure with which this material can be related in a non-arbitrary and non-literal way. Since it is the student who attributes meanings to learning materials and the meanings attributed may not be those accepted in the context of the teaching subject. This also means that the material must be relatable to your cognitive structure. This means that he attributes to the new knowledge conveyed by the learning materials the meanings accepted in the context of the teaching subject.

Therefore, the construction of meaningful learning implies the connection or linking of what the student knows with new knowledge (old and new), resulting in the rupture of the "classic" repetition to learn, leaving, as far

as possible, that teaching and learning are functional, in order to ensure the significant self-structuring of the content (PELLIZARI, et.al.2002).

Moreira (2012) continues to contribute by bringing the definition of critical meaningful learning, which occurs through social interaction and questioning. This consists of teaching/learning through questions instead of answers, in which the adoption of the book is not the only source for learning (yet another source), as documents, articles and other educational materials must be used. Therefore, the student becomes a perceiver in addition to deciding how to represent an object based on what his experience gives him.

SIGNIFICANT POTENTIAL TEACHING UNITS (UEPS) AND MODERN PHYSICS: THE CORPUSCULAR NATURE OF LIGHT AND ITS APPLICATIONS IN HIGH SCHOOL

Another instrument for the development of critical meaningful learning presented by Moreira (2011) brings the possibility of using Significant Potential Teaching Units (UEPS). Which are described by the author as didactic sequences or a set of interconnected, non-mechanical and non-memoristic activities that can stimulate applied research in teaching, that aimed directly at the classroom, with theoretically based teaching, observing the promotion of meaningful learning. Regarding this, Moreira (2011) provides 8 steps so that meaningful learning can be carried out in the classroom.

Based on the guidelines of Moreira (2011), it is aimed at teaching and learning in high school, in the field of Modern Physics, taking as a focus the corpuscular nature of light, content that makes up the basic curriculum of high school, in the present study, for 2nd year high school students.

The inclusion of Modern Physics in school, especially in high school, is an increasingly urgent need, given the relevance of production and technological advancement in society and this can be associated with everyday situations such as: xerox, laser printer, doors and taps automatic, remote control, laser in medicine, optical fibers. This would require new teaching strategies, teaching resources closer to the student's reality and how they may be interested in investigating what is behind these phenomena of new technologies that are common in society.

Within this theme, the sequence to be used in a UEPS is developed, because for learning to be meaningful it needs to be linked to a context in which the student can perceive and identify the phenomenon covered in physics classes.

It is also noteworthy that in the implementation of UEPS there is the possibility of breaking the understanding of issues linked to common sense, mathematical formalism and the carrying out of experimentation, even without physics laboratories, phenomena about light, for example, can be treated with other strategies and thus attract students to build new knowledge.

CONCLUSIONS

Critical meaningful learning, although already understood by several researchers in the country and even by the Ministry of Education, is still a challenge to be achieved in many Brazilian schools.

Therefore, teachers who teach the subject of Physics in schools need to be "innovative" and promoters of "active physics" through which their teaching and learning process is closely linked to technological developments that are present in society and are part of of the student's daily life.

This also demands the construction of potentially significant materials with the

Sequential Aspects of a UEPS.	
Step 1	Define the topic or theme that will be covered, rescuing prior knowledge and the relationships that can be established with the new knowledge.
Step 2	Provide situations in which the student can externalize prior knowledge, through discussions, conceptual maps and texts.
Step 3	Introduction to the study topic or problem situation that seeks to relate previous knowledge with new knowledge.
Step 4	Present the new content or concept to be explored starting from general aspects to more specific ones (progressive differentiation).
Step 5	Resumption of the most general aspects of the content, advancing in complexity. Promote interaction situations with students involving the negotiation of meanings.
Step 6	Approach to the study topic with a greater degree of complexity, with diversification of activities and more relevant characteristics of the new concepts explored.
Step 7	Learning assessment: recording evidence of significant learning throughout UEPS implementation.
Step 8	Assessment and Validation of UEPS according to evidence of meaningful learning.

Table 1 Sequential Model for LIFO.

Source: Prepared by the author based on Moreira, 2011.

UEPS Sequence in Modern Physics		Objective
Step 1	Topic covered: The corpuscular nature of light. Questions to students: What is light? Is a wave or a particle?	Check what the student knows about physics modern (quantum mechanics) about light and its dualism.
Step 2	Students externalize their prior knowledge. Application of internet research and the use of textbooks to verify the knowledge externalized by students.	Introduce the concept of waves and modern physics.
Step 3	Survey the content acquired by students. Make a connection with your daily life about light as a natural phenomenon. Relate previous knowledge with new knowledge.	Encourage the student to identify light in their daily lives as an element of nature and its application.
Step 4	Present the new content discovered by students, directing them from general aspects to more specific ones: Light is a wave, but also a particle.	Apply the concepts of light dualism: wave and particle and how this is and can be applied
Step 5	Resumption of concepts and progress towards complexity. Promote situations of interaction with students, involving them in the meanings of this new knowledge.	Encourage the student to relate how the dualism of light implies meanings.
Step 6	Check which of the new knowledge acquired so far has the greatest degree of complexity. Diversify teaching activities so that the most relevant characteristics of new concepts are explored.	Identify which contents were achieved by students and their progress.
Step 7	Learning assessment: recording evidence of significant learning throughout UEPS implementation.	Check how students learn about modern physics. And how LIFO can be improved for future applications.
Step 8	Assessment and Validation of UEPS, according to evidence of significant learning.	Check with students' what progress they have made with the application of UEPS in teaching and learning modern physics.

Table 2 UEPS Sequence for Teaching Modern Physics: The Corpuscular Nature of Light.

Source: Prepared by the author, 2023.

possibility of a pedagogical intervention that promotes the student's comprehensive training so that they can reflect and position themselves in the face of everyday situations: interpret them, get to know them and advance in this knowledge.

And so, when using Significant Potential Teaching Units (UEPS), it can be one of the instruments to advance knowledge, diversify teaching activities, covering varied themes, modern methods and consigning learning theories that are feasible with the school reality, contributing so that students understand the fundamental role that Modern Physics plays as a subject in high school, in addition to stimulating curiosity and awakening interest in future research, encouraging learning to be truly meaningful.

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