NEWTON'S LAWS AND THEIR TEACHING IN HIGH SCHOOL: AN INVESTIGATIVE APPROACH

LEIS DE NEWTON E SEU ENSINO NO ENSINO MÉDIO: UMA PROPOSTA INVESTIGATIVA

LAS LEYES DE NEWTON Y SU ENSEÑANZA EN LA EDUCACIÓN SECUNDARIA: UNA PROPUESTA INVESTIGATIVA

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ABSTRACT

The persistence of traditional practices in Physics teaching, characterized by excessive mathematical formalism and a content-transmission-centered approach, still hinders students' construction of meaning in secondary education. In the case of Newton's Laws, such an approach tends to privilege the mechanical application of formulas to the detriment of conceptual understanding and the problematization of phenomena. This article aims to discuss theoretical and didactic foundations for teaching Newton's Laws and to present an inquiry-based proposal aligned with the Brazilian National Common Curricular Base (BNCC), aimed at overcoming such formalism. This is a theoretical-bibliographic study grounded in constructivist frameworks and contributions from inquiry-based science education, articulating assumptions of the Science, Technology, Society and Environment (STSE) approach, elements from the History and Philosophy of Science (HPS), and the use of Digital Information and Communication Technologies (DICT). The proposal is structured around the investigation of contextualized problem situations that mobilize prior knowledge, teacher mediation for the formulation of students' hypotheses, and the conceptual systematization of the three laws of motion. As potential outcomes, this proposal fosters an inquiry-based approach that promotes the construction of meaning regarding the relationships among force, mass, and motion, expanding evidence-based argumentation and strengthening students' scientific autonomy. It is concluded that this teaching proposal contributes to overcoming formalism in the teaching of Newton's Laws, requiring pedagogical intentionality, formative assessment, and teacher education consistent with current curricular guidelines.

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Keywords: Physics Education. Newton's Laws. High School. Inquiry-based Approach. Problem Situation.

RESUMO
A persistência de práticas tradicionais no ensino de Física, marcadas pelo formalismo matemático excessivo e pela centralidade na transmissão de conteúdos, ainda dificulta a construção de significados pelos estudantes no Ensino Médio. No caso das Leis de Newton, tal abordagem tende a privilegiar a aplicação mecânica de fórmulas em detrimento da compreensão conceitual e da problematização dos fenômenos. Este artigo tem como objetivo discutir fundamentos teóricos e didáticos para o ensino das Leis de Newton e apresentar uma proposta investigativa alinhada à Base Nacional Comum Curricular (BNCC), voltada à superação desse formalismo. Trata-se de um estudo de natureza teórico-bibliográfica, fundamentado em referenciais construtivistas e em contribuições do ensino por investigação, articulando pressupostos da abordagem Ciência, Tecnologia, Sociedade e Ambiente (CTSA), elementos da História e Filosofia da Ciência (HFC) e o uso de Tecnologias Digitais da Informação e Comunicação (TDICs). A proposta organiza-se a partir da investigação de situações-problema contextualizadas que mobilizam conhecimentos prévios, mediação docente para a formulação de hipóteses discentes e sistematização conceitual das três leis do movimento. Essa proposta possibilita, como possíveis resultados, uma abordagem investigativa que favorece a construção de significados das relações entre força, massa e movimento, ampliando a argumentação baseada em evidências e fortalecendo a autonomia científica dos estudantes. Conclui-se que essa proposta de ensino contribui para a superação do formalismo no ensino das Leis de Newton, exigindo para tanto, intencionalidade pedagógica, avaliação formativa e formação docente consistente com as diretrizes curriculares vigentes.

Palavras-chave: Ensino de Física. Leis de Newton. Ensino Médio. Abordagem Investigativa. Situação-problema.

RESUMEN
La persistencia de prácticas tradicionales en la enseñanza de la Física, caracterizadas por un excesivo formalismo matemático y por la centralidad en la transmisión de contenidos, aún dificulta la construcción de significados por parte de los estudiantes en la educación secundaria. En el caso de las Leyes de Newton, dicho enfoque tiende a privilegiar la aplicación mecánica de fórmulas en detrimento de la comprensión conceptual y la problematización de los fenómenos. Este artículo tiene como objetivo discutir fundamentos teóricos y didácticos para la enseñanza de las Leyes de Newton y presentar una propuesta investigativa alineada con la Base Nacional Común Curricular (BNCC) de Brasil, orientada a la superación de dicho formalismo. Se trata de un estudio de naturaleza teórico-bibliográfica, fundamentado en referentes constructivistas y en aportes de la enseñanza por indagación, articulando presupuestos del enfoque Ciencia, Tecnología, Sociedad y Ambiente (CTSA), elementos de la Historia y Filosofía de la Ciencia (HFC) y el uso de Tecnologías Digitales de la Información y la Comunicación (TDIC). La propuesta se organiza a partir de la investigación de situaciones-problema contextualizadas que movilizan conocimientos previos, la mediación docente para la formulación de hipótesis por parte de los estudiantes y la sistematización conceptual de las tres leyes del movimiento. Como posibles resultados, esta propuesta favorece un enfoque investigativo que promueve la construcción de significados en las relaciones entre fuerza, masa y movimiento, ampliando la argumentación

basada en evidencias y fortaleciendo la autonomía científica del estudiantado. Se concluye que esta propuesta de enseñanza contribuye a la superación del formalismo en la enseñanza de las Leyes de Newton, exigiendo intencionalidad pedagógica, evaluación formativa y formación docente coherente con las directrices curriculares vigentes.

Palabras clave: Enseñanza de la Física. Leyes de Newton. Educación Secundaria. Enfoque Investigativo. Situación-problema.

1 INTRODUCTION

School education, throughout its institutionalization process, began to reflect the sociocultural contexts in which it is inserted. However, it still preserves traditional practices centered on the mechanical and decontextualized transmission of contents, characterized by low student participation and little appreciation of prior knowledge (Vygotsky, 1987; Durkheim, 1922). This model, criticized by Rubem Alves (2010) for limiting students' creativity and engagement, is described by Freire (1968) as banking education, marked by vertical pedagogical relations, absence of dialogue and weakening of problematization as a formative principle.

In the field of Physics Teaching, such characteristics are often manifested in the excessive emphasis on mathematical formalism and in the centrality of algorithmic resolution of exercises, to the detriment of conceptual understanding and the construction of meanings. Research in the area has defended methodologies aligned with contemporary demands, valuing active participation, investigation and the development of critical thinking (Nardi, 2001; Moran, 2000).

This change in perspective dialogues with the growing need to promote learning that transcends the mere application of formulas and favors the interpretation of everyday natural and technological phenomena. From a normative point of view, the Law of Guidelines and Bases of National Education (LDB) and the National Common Curriculum Base (BNCC) guide an education focused on the integral development of students, emphasizing contextualized, inclusive practices based on evidence-based argumentation (Brasil, 1996; 2018).

In the field of Natural Sciences, the BNCC highlights the investigation of phenomena, the understanding of the relationships between Science, Technology, Society and Environment (CTSA) and the construction of competencies that articulate conceptual knowledge and citizen action.

In this scenario, the teaching of Newton's Laws in High School assumes a structuring role in the organization of Mechanics, as it makes it possible to understand forces, movements and interactions present in everyday situations and in technological applications. However, when approached predominantly under formalist logic, this content tends to be reduced to the mechanical application of mathematical relations, making it difficult to understand the concepts that underlie such relations.

Overcoming this limitation implies recognizing the student as an active subject of the learning process and promoting practices that favor problematization and the construction of meanings.

In view of this scenario, this article starts from the following research question: Which didactic paths can contribute to overcoming formalism and decontextualized traditional practices in the teaching of Newton's Laws in High School, favoring the construction of meanings by students?

In line with this issue, the objective of this article is to discuss theoretical and didactic foundations for the teaching of Newton's Laws in High School and to present a proposal for didactic organization oriented to overcoming formalism and promoting conceptual learning.

From this outline, the article is organized in the presentation of the theoretical foundations that support the proposal, in the description of its principles and structuring stages and in the discussion of its implications for the conceptual learning of Newton's Laws in High School.

2 THEORETICAL FRAMEWORK

2.1 CONSTRUCTIVISM AND CONSTRUCTION OF MEANINGS IN THE TEACHING OF PHYSICS

The criticism of transmissive approaches in the teaching of Science is supported by the constructivist bases that understand learning as an active process of construction of meanings. Ausubel (1985) argues that learning becomes meaningful when new information is related in a substantive and non-arbitrary way to the student's previous knowledge. Such a perspective shifts the focus from memorization to cognitive organization and conceptual anchoring.

Vygotsky (1987) expands this understanding by highlighting the role of social mediation and language in the formation of scientific concepts, situating the Zone of Proximal Development (ZPD) as a privileged space for cognitive advancement. Learning, in this horizon, does not occur in isolation, but through guided interaction, in which the teacher assumes a decisive role in the organization of situations that enable the progressive internalization of concepts.

Piaget (1998), in turn, contributes by emphasizing the processes of assimilation and accommodation, understanding cognitive development as a continuous movement of imbalance and rebalancing. Cognitive conflict, in this context, constitutes a structuring element of the construction of knowledge. Learning Physics, therefore, is not reduced to the reproduction of mathematical procedures, but involves conceptual reorganization and establishment of relationships between different representations and experiences.

This understanding dialogues with contemporary curricular guidelines that defend the integral formation of the student and the articulation between scientific knowledge and application contexts (Brasil, 2018). The construction of meanings, in this sense, becomes a structuring axis for the teaching of classical contents of Mechanics, such as Newton's Laws, often reduced to algorithmic application.

2.2 TEACHING BY INVESTIGATION AND PROBLEM SITUATIONS

In the context of Physics teaching, teaching by investigation is pointed out as a consistent alternative to practices focused on exposure and mechanical resolution of exercises. Gil-Pérez (1993) and Cachapuz (2005) defend didactic models based on problem-situations that mobilize previous knowledge, stimulate mediation for the formulation of hypotheses and lead to the progressive systematization of scientific knowledge.

The problem-situation is not configured as a mere applied exercise, but as a structured context that provokes questions, makes alternative conceptions explicit and creates conditions for its conceptual reconstruction. In this process, teacher mediation is essential to articulate the hypotheses formulated by the students to the consolidated scientific models, avoiding both authoritarian imposition and the absence of epistemological direction.

This approach can integrate, through dialogic, elements of the History and Philosophy of Science (HFC), evidencing the historical and provisional nature of scientific models, as well as articulate relationships between STSA. The insertion of Digital Information and Communication Technologies (DICTs) expands possibilities of visualization, simulation and analysis of phenomena, as long as it is guided by clear pedagogical objectives.

By shifting the focus from memorization to investigation, teaching by inquiry favors the development of evidence-based argumentation and intellectual autonomy, aspects consistent with the competencies provided for in the BNCC for the Natural Sciences (Brasil, 2018).

2.3 FORMATIVE ASSESSMENT AND PEDAGOGICAL MEDIATION

Consistent with the investigative perspective, the evaluation assumes a formative and procedural character, overcoming the exclusive emphasis on the verification of final results. Campos and Nigro (1999) argue that evaluation should be integrated into the teaching process, allowing the monitoring of the students' conceptual evolution and guiding more precise pedagogical interventions.

Pozo (2009) expands this understanding by proposing multidimensional and continuous assessments, such as qualitative records, concept maps and contextualized activities, capable of evidencing advances, difficulties and cognitive strategies mobilized by the students. Evaluating, in this horizon, implies understanding how the student thinks and how he reorganizes his ideas in the face of new conceptual challenges.

Such an approach becomes particularly relevant in the teaching of Newton's Laws, content that often reveals persistent Aristotelian alternative conceptions related to force, motion, and interaction. Pedagogical mediation, articulated with formative evaluative strategies, contributes to making these obstacles explicit and to promoting their conceptual overcoming.

2.4 DIDACTIC TRANSPOSITION AND IMPLICATIONS FOR THE TEACHING OF NEWTON'S LAWS

Didactic transposition, understood as a process of reorganization of scientific knowledge into school knowledge (Delizoicov; Angotti; Pernambuco, 2002), is a central dimension in the discussion about the teaching of Newton's Laws. The challenge lies not only in simplifying content, but in selecting, reorganizing and contextualizing concepts in a way that preserves their scientific coherence and explanatory power.

In the case of Mechanics, the risk of formalism is manifested when laws are presented exclusively as mathematical relations, detached from their conceptual foundations and their conditions of validity. Prioritizing conceptual understanding implies making explicit that Newton's Laws apply to macroscopic systems in inertial frames (non-accelerated frames) and that outside these limits, these laws require other theoretical formulations, such as Relativity and Quantum Mechanics. This explanation favors a more consistent view of the nature of scientific models.

Materials produced by the Group for the Reelaboration of Physics Teaching (GREF, 1993) and the National Book and Didactic Material Program (PNLD) 2024 exemplify didactic reorganization efforts aligned with curricular guidelines, by integrating everyday situations, CTSA relationships, HFC elements, TDICs, conceptual problematization and investigative teaching. These initiatives reinforce the need to overcome the centrality of algorithmic manipulation and to promote inclusive practices that consider different rhythms and modes of learning.

In this sense, the framework presented here supports the defense of a teaching of Newton's Laws oriented to the construction of meanings, to intentional mediation and to the investigation and problematization of phenomena in line with the current curricular guidelines and with critical scientific training.

3 METHODOLOGY

This article is characterized as a theoretical-bibliographic research, with a qualitative approach and propositional character. Bibliographic research, as defined by Gil (2010), is developed from material already prepared, especially books, scientific articles and official documents, enabling the critical and systematic analysis of concepts and categories pertinent to the problem investigated. In this sense, the study organizes and interprets contributions from the field of Physics Teaching and Science Teaching, articulating them to the elaboration of a didactic proposal aimed at the teaching of Newton's Laws in High School.

The qualitative approach is based on the understanding of processes, meanings and theoretical constructions, prioritizing interpretation and conceptual analysis to the detriment of data quantification (Lüdke; André, 2013). Bogdan and Biklen (1994) point out that qualitative research is concerned with understanding the phenomenon in its context, seeking to interpret meanings attributed to practices and concepts. Although the present study does not involve the collection of empirical data, it shares this orientation by critically analyzing theoretical references and their implications for the didactic organization.

The methodological path was structured in two complementary movements. The first consisted of the selection and analysis of literature related to the axes that support the investigated problem: constructivist contributions to meaningful learning; fundamentals of teaching by inquiry; formative evaluation and pedagogical mediation; didactic transposition; and national curriculum guidelines, with emphasis on the National Common Curriculum Base. The analysis sought to identify theoretical convergences, conceptual tensions and gaps related to the formalistic treatment of Newton's Laws in High School.

The second movement focused on the systematization of a proposal for didactic organization based on the analyzed references. The proposal was structured based on contextualized problem situations, mobilization of previous knowledge, mediation in the formulation of hypotheses and subsequent conceptual systematization of the three laws of motion. Possibilities of articulation with CTSA relations, HFC elements, use of TDICs and formative assessment strategies integrated into the teaching process were also considered.

As this is a theoretical and purposeful study, there was no empirical application in a school context or participation of research subjects, dispensing with ethical procedures related to research with human beings. As a limitation, it is noteworthy that the proposal presented was not submitted, within the scope of this article, to empirical validation in the classroom, configuring itself as a theoretically grounded didactic organization and open to further investigation in future investigations.

4 RESULTS AND DISCUSSIONS

The analysis of the theoretical references mobilized throughout this study allowed us to organize a didactic proposal for the teaching of Newton's Laws in High School based on three articulating axes: mobilization of previous knowledge, problematization through contextualized situations and conceptual systematization mediated by the teacher. As it is a theoretical-bibliographic and propositional study, the results presented here refer to the systematization of this didactic organization and the discussion of its pedagogical implications in the light of the literature in the area.

4.1 ORGANIZATION OF THE DIDACTIC PROPOSAL

The didactic proposal is organized in sequential and articulated stages, designed to favor the conceptual reconstruction of Newton's Laws from contextualized problem-situations. Each stage involves three fundamental moments: survey of previous knowledge, problematization in groups and teacher mediation oriented to conceptual systematization.

The starting point consists of mapping the students' initial conceptions about movement, force and interaction. This survey can be carried out through a brief diagnostic pre-test, open-ended questions projected in class, or guided reading of a short text that explores intuitive notions about why objects move or stop. The objective is not to evaluate performance, but to make explicit previous ideas often associated with the conception that movement requires continuous strength to maintain itself.

4.1.1 Newton's First Law: Inertia and Frames of Reference

To introduce the First Law, the following problem-situation is proposed: what happens to standing passengers when a bus starts or brakes abruptly? Before any formalization, students are organized into small groups and are invited to discuss and record explanatory hypotheses. It is common to emerge interpretations based on the idea that the body "is thrown backwards" or "pushed forward" by a mysterious force associated with the movement of the vehicle.

At this point, the teacher assumes the role of mediator, asking the groups to explain their justifications and confront arguments. The collective discussion shows that, when the bus accelerates, the passenger's body tends to maintain the previous state of rest, going backwards; when he brakes, he tends to maintain the state of movement, going forward. From this confrontation of ideas, the principle of inertia is introduced, explaining that a body remains at rest or in uniform rectilinear motion (MRU) if the net force on it is zero.

As a historical and epistemological expansion (HFC), it is suggested the guided reading of excerpts from *Galileo's (1999) Dialogues on the two greatest systems of the world*, in which experiments with inclined planes and the notion of conservation of motion in the absence of resistance are discussed. The analysis of these excerpts makes it possible to highlight the rupture with Aristotelian physics, which associated movement with the continuous action of a force, conceptually preparing the ground for the Newtonian formulation of the principle of inertia. This moment contributes to the students' understanding that scientific concepts result from historical processes of debate and overcoming previous models.

After the discussion, conceptual systematization is carried out: inertia is presented as a property related to the mass of the body, understood as a measure of resistance to the variation of the state of motion (GREF, 1993). Situations such as the use of seat belts, airbags and the movement of satellites in orbit are analyzed to consolidate the understanding of the principle in different contexts, such as the analysis of CTSA relationships. At this point, the limits of validity of Newton's Laws are also explained, highlighting that they apply to macroscopic systems, in inertial frames and at speeds much lower than the speed of light.

4.1.2 Newton's Second Law: Relationship between force, mass and acceleration

To address the Second Law, the investigative logic is resumed. The proposed new problem-situation involves two identical supermarket carts, but one empty and the other loaded with bottles of water, both initially at rest. The question is: what is needed to set them in motion? In which of them is it more difficult to move it, applied to the same force? What happens if we apply the same force to both?

Students discuss in groups and record their hypotheses. They often recognize that the loaded cart requires "more effort," but they do not always articulate this perception with the quantitative notion of mass as a measure of inertia. Teacher mediation leads to the analysis that the variation of movement depends on the net force applied and the mass of the body, and it is also up to the teacher to relate this situation to the conceptual elements discussed in the First Law (inertia and mass) (GREF, 1993).

Formalization occurs gradually. It is based on the idea that the net force is associated with the variation of movement over time (acceleration). In High School, for constant mass, this relationship is expressed by:

$$F_r = m \cdot a \qquad (1)$$

It is explained that:

represents the net force (N), mass (kg), and acceleration (m/s²). The focus is not only on calculation, but on interpretation: all acceleration results from the action of a net force and, for the same force, bodies of greater mass have less acceleration.$F_r ma$

To consolidate this understanding, a contextualized example is analyzed: a 1200 kg car that travels at 20 m/s and suffers a braking force of 6000 N. The application of equation (1) leads to a (de)acceleration of −5 m/s². The physical meaning of the result is discussed: the velocity decreases by 5 m/s every second while the force acts (hence the negative sign). This moment is decisive to prevent the equation from being perceived as a mere algorithmic tool, emphasizing its explanatory power. Later, having explained the third law, one can return to this example and detail it by discussing Newton's three laws in this same situation.

Situations involving acceleration and braking of vehicles, sports practices or displacement of loads expand the analysis and favor the articulation of this law in contexts such as the analysis of CTSA relations.

4.1.3 Newton's Third Law: Interactions and pairs of forces

The Third Law is introduced from a problem-situation involving an athlete kicking a suspended sandbag. The question is: if the athlete applies force to the bag and puts it in motion, why does he feel pain on impact and is "pushed back"? Group discussion allows for the explicit of alternative conceptions, such as the idea that only the object "receives" the force.

Teacher mediation leads to the understanding that forces are interactions between bodies. By exerting force on the sac (, the athlete simultaneously receives a force of the same intensity and direction (, but in the opposite direction (hence the negative sign). This relationship can be expressed by:$\vec{F}_{AS})\vec{F}_{SA})$

$$\vec{F}_{AS} = -\vec{F}_{SA} \qquad (2)$$

Examples such as rocket propulsion, jumping, and vessel displacement reinforce the interactional character of the forces and broaden conceptual understanding in different contexts, such as the analysis of CTSA relationships.

To deepen the study of Newton's Laws, it is also possible to problematize whether the First Law constitutes a particular case of the Second. Although relation $\vec{F}_R = m\vec{a}$ (1) suggests that the absence of acceleration implies a net force of zero, this interpretation is conceptually insufficient. The Second Law expresses a classical deterministic model that describes everyday macroscopic phenomena, but does not exhaust the foundations of Newtonian mechanics nor does it apply to relativistic or quantum domains (Nussenzvieg, 1997).

It is inferred, therefore, that Newton's First Law is not a particular case of the Second. Its essential function, although it is compatible with the condition of a = 0 m/s², implied in Fr = 0 N, is to establish the existence of inertial frames, a necessary condition for the validity of Newton's three Laws and of the entire formalism of classical mechanics.

4.1.4 Integration of digital resources and formative assessment

Throughout all stages, it is recommended to use interactive simulations, such as those provided by Physics Education Technology (PhET), to explore vectors of force, balance and motion. Simulations should be accompanied by guiding questions that require qualitative interpretation before mathematical formalization.

The evaluation occurs in a procedural way, through written records of hypotheses, debates, collective syntheses and resolution of contextualized problems. This monitoring allows the teacher to identify conceptual advances and persistent difficulties, adjusting pedagogical interventions.

4.2 DISCUSSION OF THE RESULTS IN THE LIGHT OF THE LITERATURE

The systematized didactic organization shows convergence with the constructivist bases discussed in the theoretical framework. The mobilization of previous knowledge and the confrontation of hypotheses dialogue with the perspective of meaningful learning, as new information is anchored in existing cognitive structures. Cognitive conflict, triggered by problem situations, favors conceptual reorganization, as pointed out by classic studies in the area.

The centrality of teacher mediation proves to be a decisive element to avoid both formalistic imposition and the absence of conceptual rigor. By articulating student hypotheses to consolidated scientific models, the professor preserves the epistemological coherence of the content, without reducing the student to a mere executor of algorithmic procedures.

The results of the systematization indicate that the investigative approach contributes to shift the focus from the calculation to the physical interpretation of the relationships between force, mass and motion. By integrating everyday situations, limits of validity of laws and discussion of inertial references, the understanding of the nature of scientific models is expanded, overcoming simplifying views often present in textbooks.

The articulation with CTSA relations and with digital resources strengthens the contextualization and expands the formative reach of the content, in line with the competencies provided for the Natural Sciences. In addition, the incorporation of formative assessment throughout the process allows for the monitoring of the conceptual evolution of the students, favoring more precise pedagogical interventions.

In general, the results discussed indicate that the overcoming of formalism in the teaching of Newton's Laws does not depend on the elimination of mathematics, but on its reintegration into a process of construction of meanings. When inserted in an investigative, mediated and contextualized path, laws cease to be formulas to be applied mechanically and constitute explanatory instruments to understand phenomena of the physical world.

Thus, the proposal presented reaffirms that the teaching of Newton's Laws, guided by problematization, intentional mediation and formative evaluation, can consistently contribute to the critical scientific education of high school students, in line with the current curricular guidelines and with the contemporary demands of Physics Teaching.

5 CONCLUSION

This article aimed to discuss theoretical and didactic foundations for the teaching of Newton's Laws in High School and to present a proposal for didactic organization oriented to overcoming formalism and promoting conceptual learning.

In response to the research question, it is argued that the overcoming of traditional decontextualized practices and excessive mathematical formalism passes through didactic paths that replace the student at the center of the learning process, articulating prior knowledge, problematization and intentional teacher mediation, in order to transform the laws of motion into explanatory instruments to interpret real situations and not just formulas to be applied mechanically.

The results of this study, of a theoretical-bibliographic and propositional nature, consist of the systematization of a didactic proposal anchored in contextualized problem situations for Newton's First, Second and Third Law, with explicit stages of diagnostic survey, group discussion, formulation of hypotheses, confrontation of ideas and conceptual systematization.

The incorporation of CTSA relations, elements of HFC, as well as the guided use of DICTs, expands the possibilities of visualization and argumentation, preserving conceptual rigor. It is a viable proposal for application in High School, as it is based on everyday situations, accessible didactic resources and strategies that can be integrated into the teacher's regular planning, without requiring complex structural changes in the curriculum.

From a formative point of view, the proposal reinforces that the teaching of Newton's Laws gains consistency when supported by formative and procedural evaluation, capable of making persistent alternative conceptions visible and guiding pedagogical interventions along the way. In line with the BNCC and the current curricular guidelines, the organization presented contributes to a Physics Teaching more aligned with contemporary demands, by favoring evidence-based argumentation, critical reading of everyday phenomena and a more rigorous understanding of the modeling character of physical laws.

As a limitation, as it is a theoretical and purposeful study, the proposal was not applied empirically in the scope of this article. Future investigations, through intervention research or case studies, may analyze its implementation in different school contexts, examining its effects on conceptual learning and on the overcoming of alternative conceptions. Even so, it is argued that the didactic reorganization presented offers consistent foundations to face the formalism in the teaching of Newton's Laws, strengthening a more critical and meaningful scientific education in High School.

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REFERENCES

Alves, R. (2010). Conversas com quem gosta de ensinar (13ª ed.). Papirus.

Ausubel, D. P. (1985). Aquisição e retenção de conhecimentos: Uma perspectiva cognitiva. Plátano.

Bogdan, R., & Biklen, S. (1994). Investigação qualitativa em educação: Uma introdução à teoria e aos métodos. Porto Editora.

Brasil. (1996, 20 de dezembro). Lei nº 9.394, de 20 de dezembro de 1996. Estabelece as diretrizes e bases da educação nacional. Diário Oficial da União.

Brasil. Ministério da Educação. (2018). Base Nacional Comum Curricular. MEC.

Cachapuz, A., et al. (2005). A necessária renovação do ensino de ciências. Cortez.

Campos, M. C., & Nigro, R. G. (1999). Didática de ciências: O ensino-aprendizagem como investigação. FTD.

Delizoicov, D., Angotti, J. A., & Pernambuco, M. M. (2002). Ensino de ciências: Fundamentos e métodos. Cortez.

Durkheim, É. (2007). Educação e sociologia. Melhoramentos.

Freire, P. (1968). Pedagogia do oprimido. Paz e Terra.

Galilei, G. (1999). Diálogo sobre os dois máximos sistemas do mundo. Nova Cultural.

Gil, A. C. (2010). Métodos e técnicas de pesquisa social (6ª ed.). Atlas.

Gil-Pérez, D. (1993). Contribución de la historia y de la filosofía de las ciencias al desarrollo de un modelo de enseñanza/aprendizaje como investigación. Enseñanza de las Ciencias, 11(2), 197–212.

Grupo de Reelaboração do Ensino de Física. (1993). Física (Vols. 1–3). EDUSP.

Lüdke, M., & André, M. E. D. A. (2013). Pesquisa em educação: Abordagens qualitativas (2ª ed.). EPU.

Moran, J. M. (2000). Novas tecnologias e mediação pedagógica (6ª ed.). Papirus.

Nussenzveig, H. M. (1997). Curso de física básica: Ótica, relatividade e física quântica (Vol. 4). Edgard Blücher.

Nardi, R. (Org.). (2001). Pesquisas em ensino de Física. Escrituras.

Piaget, J. (1998). A formação do símbolo na criança. LTC.

Pozo, J. I. (2009). Aprendizes e mestres: A nova cultura da aprendizagem. Artmed.

Vygotsky, L. S. (1987). A formação social da mente. Martins Fontes.