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PROBLEMATIZATION AND CONTEXTUALIZATION IN THE TEACHING OF PHYSICS AND THE CONTRIBUTION OF THE HISTORY OF SCIENCE.

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Abstract

This paper discusses the daily life of teachers in schools, highlighting their difficulties in obtaining satisfactory results in the teaching-learning process. The objective of the paper is to present and describe a proposal for a didactic sequence as a way of expanding the possibility of student involvement in the search for knowledge that enables them to solve everyday problems and understand the world around them, through problematization and contextualization in the approach to the theme "quantity of movement and its conservation". As a methodology, a qualitative approach was chosen, in which works from the area of historiography and didactics of sciences in the current bibliography were explored, seeking to expand the possibilities of students in their appropriation/construction of non-compartmentalized knowledge, but intertwined with other ways of interpreting the world.

Keywords: Teaching-learning. Didactic Sequence. Problematization and Contextualization. Quantity of Movement.

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1. INTRODUCTION

The research developed initially presents a reflection on the daily lives of teachers within the school and has as a backdrop their difficulties in thinking of methodologies with the potential to involve students in the construction of knowledge proposed by the educational system. Based on the assumption that the history of science can be an excellent aid (DANHONI NEVES, 1998) in the search for better results in the teaching-learning process, some considerations will be made about versions considered problematic – historical distortions – that can compromise the objectives expected from the use of the history of science in pedagogical work.

To get around one of the obstacles to the use of the history of science, represented by the lack of reading habits among young people and adolescents, we use here a didactic sequence to study the topic of momentum and its conservation, through problematization and contextualization, seeking to provoke in the student the need for knowledge that they do not yet have, which enables them to solve problems arising from their interaction with the natural world and with society. To present the proposal, the methodological basis chosen was Delizoicov apud Ricardo (2010), Baldinato and Porto (2008), Neto (1999), Gil-Pérez et al (2001) and Forato, Martins and Pietrocola (2009, 2011 and 2012). From a qualitative approach, it was concluded that the didactic sequence, and more specifically, the process of problematization and contextualization, has the potential to awaken in the student intentions towards the construction of knowledge that escapes the compartmentalizations derived from a Cartesian and excluding perspective of knowledge itself.

The contact between teaching professionals in the moments before the start of activities and during breaks makes the school environment, more specifically the teachers' lounge, the privileged space to capture "snippets" of the situation of science teaching in basic education, offered by public schools. In the "outburst" of Physics teachers who work in first-year high school classes, the difficulties students have in learning topics related to force and movement come to light, reflected in low performance, lack of interest, indiscipline and dropping out of school - thus configuring a process of exclusion from the possibility of building and fully experiencing citizenship. When asked, the students respond that the subject is difficult, with excessive and boring calculations, without any meaning for them. It is clear, then, that for these students, Physics would not be missed at all if it were no longer part of the school curriculum. From the teachers' and students' speeches, evidence emerges that allows us to conclude that, in light of research in science teaching (EL-HANI, 2006; CACHAPUZ ET AL, 2005; RICARDO E FREIRE, 2007; REZENDE & OSTERMANN, 2005, NARDI, 1998) and the guidelines contained in official documents – Laws of Guidelines and Bases of National Education (BRAZIL, 2020), National Curricular Parameters (BRAZIL, 2020) and State Curricular Guidelines (PARANÁ, 2020) (insert the year of each document) – one of the possible causes of the setbacks in science teaching is due to gaps in teacher training, whether in their undergraduate courses or in the continuing education policy. We come across a large number of teachers who, lacking a theoretical framework, act like the prisoners in Plato's[1] myth of the cave, since, by adopting mistaken methodologies, they think they are on the right path and end up transferring the responsibility for failures in the knowledge construction process to their students.

This situation is made worse if we consider that in the public schools of the state of Paraná, Physics is taught in only two classes per week, requiring teachers to undertake the difficult task of selecting, organizing and articulating the content in order to form a backbone that structures the physical knowledge that will be constructed and appropriated by students during the school year. But wouldn't this search for a harmonious articulation of the selected content be the object of criticism by a movement that occurred in the last century and that opposed the concept of fragmented and rationally sequenced teaching of science?[2] This antagonism – between the school we have and the school we want – in thinking about science education is highlighted when the use of the History of Science in Physics Teaching is brought into the debate. Teachers who are fascinated by the History of Science, when appropriating some knowledge about the History and Philosophy of Science, realize that the History of Science is incompatible with the logical and sequential nature of Physics. Warning about the need to be careful about using the History of Science in science teaching, Martins (2006, p. xxvii) highlights the relevance of this endeavor, stating that "[...] There is only one way to acquire scientific knowledge [...]. It is through the study of the history of science – but not Whig historiography". So, how can we work with this structuring content, from a historical perspective?

Whig historiography is an expression introduced by historian Herbert Butterfield to refer to history characterized by interpreting past events in light of the present. This type of history "retains" the events in which science triumphs, disregarding those that in light of the present are considered unscientific or irrational. According to Lombardi (1997, p. 345),

> [...] it will eliminate from the history of science theories that are "erroneous" in light of later science, unless they are analyzed to point out the retrograde character of those who supported them; it will also eliminate factors that today we consider unscientific or irrational.

On the one hand, as Lombardi (1997) explains, we have voices that are against the use of the History of Science in the teaching of Physics, such as Klein, Brush, Allchin and Whitaker, and on the other, positions such as Kuhn's, in favor of distorted insertions of the History of Science. Siegel apud Silva and Laburú (2010), argues that Kuhn defended distorted versions of the History of Science with the aim of instilling in the student the current dominant paradigm. In addition, he was against the use of the undistorted history of science, believing that it could be harmful to the science student. Which approach should we choose?

As a suggestion, as an example of a phenomenon to be investigated, we proposed the occurrence of a traffic accident on a highway, from which the teacher introduces and leads the student

[1] Plato illustrates the hierarchy of forms of being and the conversion to the intelligible: the inhabitants of a cave, prisoners chained since forever, with their backs to the entrance, perceive in the background the shadows projected by objects carried by men passing by outside, and take these shadows for realities. (BARAQUIN; LAFFITTE, 2007, p. 238).

[2] According to Alves Filho (2010), this is a movement that occurred in the context of developing a curricular proposal for teaching Physics in the United States (Harvard Project Physics) from 1962 onwards.

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to an exercise of questioning, thus highlighting the interdisciplinary nature of the Didactic Sequence, as it allows the construction of bridges of connection with other areas of knowledge. This pedagogical moment, called problematization, allows students to gather elements that will help them re-elaborate the concept of momentum and its conservation. In order for students to have a richer set of data that can help them structure their thoughts, a series of simple experiments are proposed, designed and/or carried out, which, when properly explored, will serve as support for the learner to outline a plausible explanation for them. Although this work begins with considerations regarding the historiography of science, it is proposed to use the history of science in the pedagogical moment of knowledge organization, where students seek in the history of science to learn about the paths taken by scientists and philosophers, thus understanding the mathematical formulation of the concept of momentum and its conservation. In the pedagogical moment of knowledge application, students are asked to solve the problems raised with the help of the studies carried out, through the socialization of the results of the work. A written test after these activities can serve as a guide for the teacher to reflect and evaluate his/her methodology. (You gave a good explanation of how you will present the research, but your organization needs to be clearer in: “Historical distortions”, “The history of science in the classroom”.

2. HISTORICAL DISTORTIONS

Some voices have been raised against the use of the History of Science in science teaching. Martin Klein, for example, argues that by using historical materials in science teaching, the teacher ends up selecting ideas that are related to those of today, thus causing a distortion of the History of Science. According to Klein apud Lombardi (1997, p. 344), “[...] any attempt to present scientific content from a historical perspective implies selecting, organizing and presenting these historical materials non-historically, or perhaps anti-historically [...]”.

Whitaker apud Lombardi (1997, p. 344), in a paper presented in 1979, follows the same line of argument as Klein, pointing out that,

> [...] The history used in science courses is in reality a quasi-history, as it constitutes “the result of countless books by authors who felt the need to give life to their explanations [...] with a little historical content, but in fact they rewrote the history step by step to accommodate it with Physics [...].

Whitaker (1979) cites an account of the work of Planck and Rayleigh-Jeans as an example of quasi-history. In a book review, it is stated that the failure of the Rayleigh-Jeans law to describe black-body radiation made it possible to develop Planck's quantum hypothesis. It is a rewriting of the History of Science so that the facts fit into a sequence that conveys the idea of a logical and linear evolution. The Rayleigh-Jeans equation was wrong and Jeans corrected it in 1905, but Planck had presented his work at the German Physical Society on December 14, 1900.

Silva (2010, p. 13) describes one of the characteristics of what is a quasi-history, when referring to the presentation of the History of Science based on the reconstruction of historical facts:

> In this approach, it is common for the scientific ideology of the author or historian of science, who narrates the historical facts, to prevail. In this way, it is common for mistakes by great thinkers, such as Isaac Newton, Galileo and Einstein, to be rejected or even erased from history, with the purpose, almost always previously defined, of extolling the genius of the scientist.

Therefore, when we come across reports that claim to be historical, which convey the idea that the “discoveries” were readily accepted by the community upon their publication, conveying an aura of greatness about the scientists, we are faced with a “quasi-history”. This is constructed in such a way that the scientific concepts are presented in an ordered sequence, in tune with Physics, inducing the reader to think that the ideas arose in a logical and ordered sequence, which does not correspond to the reality of the facts. According to Moreira (2012), the intention of this version is more focused on clarifying and linking ideas than on considerations related to historical contextualization. For Whitaker (1979), such a distorted account ends up hindering the process of teaching and learning science, since the student sees the scientist at a level that is difficult for ordinary “mortals” to reach. According to this author, Brush sees quasi-history as a distortion of history, resulting from the attempt to subject reports of scientific discoveries to the norms of the objective scientific method.

Neves (2002), citing Darnton, refers to children's stories – Little Red Riding Hood, Sleeping Beauty, Cinderella, Hansel and Gretel, among others – as examples of distortions suffered by history. Such stories, originating in a context of violence, are told to children, completely “purified” of unpleasant components.

While Martin Klein and Douglas Allchin draw attention to what they call pseudohistory, Whitaker is concerned with what he calls quasi-history. Allchin (2004, p. 186) states that “[...] Pseudo-history conveys false ideas about the process of science and the nature of scientific knowledge, even if based on recognized facts”. For Matthews (1995, p. 174),

> [...] quasi-history is not just what Klein calls pseudo-history, or simplified history, where errors can occur due to omissions, [...]. In quasi-history there is a falsification of history with the appearance of genuine history, similar to what Lakatos called “rational reconstructions” of history (1978), where history is written to support a certain version of scientific methodology and where historical figures are portrayed in light of the current orthodox methodology.

Whitaker (1979, p. 109) observes that “[...] the concept of “rational reconstruction” of history, due to Lakatos, has an apparent similarity with quasi-history [...]” and explains that “Lakatos’ rational reconstruction would be that version that should have happened, “[...] if scientists had been strictly rational [...]”. Whitaker also highlights another work by Lakatos (1970), in which a text of reconstructed history was given footnotes explaining what really happened, as a result of the fact that scientists were not rational. He believes that the method of rational reconstruction can be useful for teaching science, as long as the teacher makes it clear that it is a reconstruction and that quasi-history does not admit that there was reconstruction.

By stating that his concern is not with false history, but with pseudo-history, Allchin (2004, p. 186) reinforces the criticism of this form of historical distortion, which inflates the genius of the researcher:

> [...] for example, a romanticized history of discovery may emphasize the contributions of an individual,

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> minimize the role of accidents or mistakes, simplify the investigative process, disguise less noble motivations, hide the influence of personal or cultural values, as illustrated in the Harvey case. It transforms real science into an idealized imaginary science [...][3].

Both Matthews (1995) and Lombardi (1997) oppose the arguments of historians who are against the use of the History of Science in Physics teaching, questioning the objectivity of history. For Lombardi (1997, p. 346), "[...] there is no single correct way to write history". If there are strong criticisms against the view of science as a set of immutable truths, history should be even more subject to such criticism, since every historian, when reporting a certain historical fact, does not do so in a neutral manner, because according to Lombardi (1997, p. 346), the historian makes a choice and "[...] the choice is inevitable as the historian moves within his or her own social, religious, political or ideological limits [...]". Matthews recognizes the importance of Klein and Whitaker's concerns, but disagrees that the problems mentioned constitute insurmountable obstacles. According to Baldinato and Porto (2008, p. 6),

> [...] Matthews' main argument seems to be that the activities of the historian of science and the science educator are very different, have different goals and methods – therefore, they could not be judged by the same criteria [...].

Harvey Siegel also sides with those who oppose the insertion of distorted versions of the history of science in science teaching. However, Silva and Laburú (2010, p. 79) draw attention to the inconsistency of Siegel's defense of "[...] Project Physics as a good example of this insertion without distortions [...]". The Harvard Project Physics, known as the Project Physics Course, even using "undistorted" historical narratives, uses modern resources to discuss some concepts. For example, in Unit 1, when studying the concepts of movement, the text uses the resources of algebra to discuss the equations of movement. But according to Bastos Filho (2012), in his Discorsi of 1638, Galileo uses the geometry of the Greeks. Wouldn't this be a whig version of the history of science?

Bastos Filho (2012) draws attention to the case of the laws of thermodynamics, citing an observation by Feynman, Leighton and Sands regarding the fact that the Second Law of Thermodynamics was discovered before the First Law. In Unit 3 of the *Harvard Project Physics (HPP)*, page 64, there is a mere reference to the date (1847) when the *Law of Conservation of Energy* (First Law of Thermodynamics) was mentioned in an article by Hermann von Helmholtz. On page 93, when discussing the formulation of the Second Law, there is a brief reference to the date of its publication (1824) in a book by Sadi Carnot. Pertinently, the Teacher's Guide makes the warning mentioned by Silva and Laburú (2010, p. 79) "[...] This, like all summaries, makes the facts sound more organized and systematic than they actually are. (HPP, 1978, p. 14) [...]".

While researchers such as Forato, Pietrocola and Martins (2009, 2011, 2012) are radically against the use of reports characterized as Whig historiography in the teaching of Physics, Lombardi (1997) understands that current historiography points to the adoption of an intermediate position between anachronism and diachronism, as a way of opposing the dogmatism constituted by the single approach for all cases.

Another form of historical distortion is called by Allchin (2004) false history, which would be related to cases of lack of historical accuracy (dates) or mistakes arising from popular anecdotes, such as, for example, the apple falling on Newton's head, Galileo abandoning spheres from the top of the Leaning Tower of Pisa, Archimedes shouting "Eureka" while running naked through the streets of Athens, among others. Martins (2006, p. 186) warns of the hindrance and obstacle to scientific literacy when teachers tell the anecdote about the falling apple in class, as it conveys the view that "[...] the development of science would be the result of chance" and "that it would be produced by people who suddenly 'have an idea' and then everything becomes clear".

In Martins' (2006) understanding, contrary to what the anecdotes tell, the falling apple was not responsible for helping Newton "discover" gravity. To think this way is to ignore the fact that those who lived before Newton were familiar with the term gravity. When Newton was resting and witnessed the falling apple, he had already completed a whole path of studies and research on the subject, drawing on the contributions of those who preceded him, such as Descartes, Kepler and Galileo. Martins (2006, p. 186) notes that

> [...] Gravity was already well known (and already had a name) before Newton. Since Newton had been thinking about the subject for a long time, the apple simply triggered a series of ideas – but they could have arisen without the apple falling. The most important thing was that all of Newton's research had taken place before the apple episode. Without that, nothing relevant could have been triggered by the apple falling. Besides, if Newton had just had an idea and been content with that, he would not have made an important contribution to science.

3. THE HISTORY OF SCIENCE IN THE CLASSROOM

No matter how good the quality of the textbook, analyzed, approved and recommended by the team of research teachers within the scope of the National Textbook Program for Secondary Education of the Ministry of Education and adopted by the teacher in the school where he/she works, the teacher often finds himself/herself needing to seek alternative or complementary materials to the didactic works used in the classroom. However, such materials, as a rule, the result of research work in the academic sphere, are not always within the reach of the practicing teacher. While in the academic sphere, discussions among historians of science have had repercussions within the community of science educators, as suggested by Baldinato and Porto (2008), in the context of basic education the echo of these discussions is almost inaudible, as pointed out by Neto (1999), due to the lack of interactions between basic education and higher education. Teachers often find themselves forced to produce their own materials on the History of Science, writing texts and developing teaching sequences, thus running serious risks, according to Gil-Pèrez et al (2001, p. 126), of constructing "[...] empirical-

[3] This is an excerpt from an article that presents a reflection on how the history of the blood flow theories of Galen and the English physician William Harvey was constructed. In this, the author denounces the inclusion of historical artifices, such as the omission of previous thinkers, the defamation of Galen and a hagiographic treatment of Harvey.

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inductivist views of science that are far removed from the way in which scientific knowledge is constructed [...]".

When producing their own texts, teachers find themselves caught between two schools of thought, antagonistic to the use of the History of Science in teaching Physics. One condemns the use of Whig historiography, which contributes, according to Lombardi (1997, p. 345), to materializing a view of "[...] science as an autonomous and supra-historical entity". And the other, pressured by the limited workload of the discipline in the curriculum, in which the teacher is tempted, in the process of didactic transposition, to rewrite the History of Science, placing the facts not in chronological order, but in a logical and linear sequence. This rational reconstruction results, according to Bastos Filho (2012, p. 76), "[...] from the need to use a mechanism to present cognitive shortcuts that aim at a faster understanding, without great losses of intrinsic content and without the need to delve into the complex meanders of the history of ideas".

The need to produce or adapt historical materials to the cognitive level of basic education students requires teachers to pay extra attention in order to remain alert from the perspective of history and epistemology. This adaptation refers to the need to satisfy not only the prescriptions of historiography and epistemology, but also the demands of science teaching. According to Forato, Pietrocola and Martins (2011), it is at the confluence of these three aspects that the challenges for the construction of school knowledge lie, the processes of which are posed by didactic transposition.

One way to minimize the risk of forming inadequate conceptions of science would be to follow the recommendations of Forato, Martins and Pietrocola (2009, 2011 and 2012) which, combined with the proposals of Holton apud Alves Filho (2010, p. 90) to adopt a "connective approach, would favor the formation, not of a "string of pearls", but of a tapestry of cross-connections between many fields", since the connective approach allows the study of scientific themes to be articulated with history, philosophy, sociology, politics, etc., contributing to the cultural enrichment of the student. This would be ideal, but often, due to the contingencies imposed on us, the teacher is left with only the alternative of using "rational reconstructions", carefully elaborated with regard to historiographical observations. This is justified by the need to consider the student's cognitive level, taking care to take into account Whitaker's (1979) recommendation, in the sense of making it clear to the student that this is a reconstruction.

4. PROBLEMATIZATION AND CONTEXTUALIZATION: MOBILIZATION FOR LEARNING

All the beauty of theoretical constructions will not be able to be visualized and appropriated by our children, young people and adults, if the habit of reading is not cultivated during school life. This is an obstacle to the didactic transposition of the history of science into the classroom. Therefore, it is advisable not to restrict the approach to content solely from a historical perspective, requiring students to read long texts, because, according to Forato, Martins and Pietrocola (2012, p. 145), "[...] reading is not a common practice among high school students". It is necessary to combine the historical approach to content with other ways in which students can see and/or attribute meanings to the knowledge that they are proposed to construct. We believe that an alternative would be to begin the study by creating problem situations, linked to the world lived and experienced by students. This strategy can provide opportunities for the interweaving of concept learning, problem solving and laboratory practice.

According to Gil-Pérez et al (1999, p. 312), "[...] a teaching model is more than a set of dispersed and interchangeable elements: it has a certain coherence and each of its elements is supported by the others [...]". For these researchers, in the development of research in the field of science teaching, it has become mandatory to "[...] be aware that isolated, disconnected treatments are ineffective and that a global reconsideration of the entire science teaching-learning process is needed, coherently integrating different aspects that have been studied separately until now".

What is proposed here is teaching through investigation, where the student sees himself as the subject of his knowledge, based on a situation he has experienced, which is problematized through discursive interactions mediated by the teacher. In these debates, the student verbalizes his thoughts, allowing the teacher to perceive what his worldviews are, what his conceptions of science are, and thus make decisions in guiding the course of the discussions. It is important for the teacher to be careful not to individualize the authorship of a given conception, to avoid embarrassment that may inhibit the student's participation in the debate. This form of approach and direction is not a process of "learning through discovery", but a process of collective search for an answer to a problem experienced by the community. According to Gil-Pérez (1999, p. 313), current criticisms are no longer limited to denouncing Only

> [...] the inductivist conceptions and the rigid, algorithmic views of the so-called 'scientific method'. Now, however, the criticism extends to other equally common deformations (Gil, 1993b and 1997; Fernández, 1995; Orozco, 1995) that, by action or omission, transmit teaching (aproblematic, exclusively analytical, individualistic, socially neutral vision...).

4.1 Constructing a problem situation to structure the learning situation of the concept "Quantity of Movement and its Conservation".

A fact that hardly escapes the student's observation in their interaction with the world around them is the occurrence of traffic accidents. We propose, for example, to bring to the classroom context an accident that occurred on the highway that connects the cities of Apucarana (PR) to Ponta Grossa (PR), in a stretch just after the descent of Serra do Cadeado, in the direction of those going to Ponta Grossa. The accident occurred at approximately 2:00 am on August 19, 2014 and was caused by a truck driver, who continued on his way as if nothing had happened. Caught by surprise and also due to lack of habit, those who witnessed the accident did not take any photographs of it. Therefore, we thought it was pertinent to create a physical configuration or scenario of the accident, using toy cars and through a sequence of photos, trying to convey to the reader an idea of the occurrence.

It would be interesting if, at first, the teacher or someone else did not describe how the accident happened, but asked the students for their guesses about what the photos were intended to show and explain. This would be a way of encouraging the students to exercise their imagination, a resource that has played an important role in the construction of theories and models to explain phenomena, such as those that Classical Physics was unable to explain. Thus, as the teacher presented the photos on slides or

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printed on paper, an exchange of opinions among the students could transform the classroom into a space where the student feels included and encouraged to express his or her thoughts, becoming the subject of his or her own learning. Only then would the teacher tell his or her version of the facts.

In the direction of Apucarana-Ponta Grossa, three large trucks were traveling in a line ahead of those who witnessed the event. In the opposite direction, a passenger car was traveling in front of a large truck. Being at the beginning of the third lane, this truck started to overtake the passenger car in the additional lane. Suddenly, the second truck of those that were following in line towards Ponta Grossa also started to overtake the truck in front, without paying attention to the fact that in the opposite direction, the passenger car was coming, which was being overtaken by the truck that was traveling in the same direction as it. The driver of the passenger car, seeing himself on the verge of colliding with the truck invading his lane, swerved the car to the right, positioning himself in front of the truck that, at this point, was parallel to him. Inside the vehicle that was following behind the three trucks, heading towards Ponta Grossa, those who witnessed it heard the sound of metal being crushed.

4.2 Timeline

The three pedagogical moments	Activities	Estimated time
Problematization/contextualization	- facts of life in the classroom context - problematizing an occurrence - questioning nature (experiments)	3 classes
Organization of knowledge	- seeking in the history of science, insights for structuring thought - proposing some qualitative, open questions and some numerical problems, which allow building a bridge with other areas of knowledge	2 classes
Application of knowledge	- Socialization of proposed solutions to the problems raised - Written test	2 classes

4.3 Illustrating the accident simulation through photos

Figure 1

Figure 2

Figure 3

Figure 4

Figures 1,2,3,4 – simulation of the trafic of the cars resulting in an accident.

4.4 Problematizing the incident

After everyone is aware of the circumstances of the accident, the problem can be solved. The teacher and/or students can ask a series of questions about various aspects involved. For example:

- What would have been the reaction of the driver who was trying to overtake the passenger car when he saw it suddenly position itself in front of him?
- Without mentioning the numerical value, what would have been the speed of the truck in that time interval, in relation to the speed of the passenger car: higher, equal or lower?
- If the speed were higher, even if he immediately applied the brakes, would the driver have been able to avoid hitting the back of the car? Why?
- And if the speed were the same as the car, would the truck driver have been able to stop the vehicle relatively quickly? Comment.
- Two vehicles, with different masses (a passenger car and a truck), have the same speed. Which of the two is harder to stop? Why?
- Two vehicles of different masses (a passenger car and a truck) are both at rest. Which of the two is easier to put into motion?
- During the braking process, which of the two vehicles mentioned travels the greatest distance before stopping? What is your hypothesis to explain your answer?
- What could have led the driver who caused the accident to overtake in unfavorable conditions? What ethical issues are implied by his attitude (avoiding the scene)?
- Could the accident have occurred if the highway had dual carriageways? Comment.
- What suggestions would you make to minimize the occurrence of these types of accidents?

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4.5 Interrogating nature (experiments)

To gather a greater amount of data to support discussions, a practical activity could be carried out, which would consist of observing the movement of a sphere, which, when dropped at any point on the inclined part of a gutter, travels a certain distance on the horizontal part until it stops, due to the force of friction, as illustrated below. Ask a student to drop two spheres of different dimensions, starting from the same position, one at a time, and observe the distance that each of them travels on the horizontal part of the gutter.

Figure 1: track and sphere

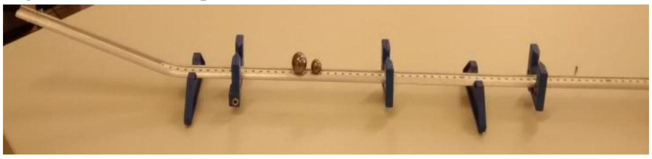

Figure 2: track and two spheres

- the two spheres, dropped from the same height, one at a time, reach the beginning of the horizontal section at different speeds or at the same speed?
- why does the larger sphere travel a greater distance on the horizontal section, if both were dropped from the same height?

Returning to the points that were discussed in the problematization, students could be asked to work in groups and develop an explanatory model about the movement of each sphere of the experiment and of each vehicle involved in the accident, which would gather and articulate the observed data, through a mathematical formulation. At the end of a previously agreed time, the teacher will record the contributions of each group. If necessary, present the following formulations in the form of a complementary proposal:

$$Q = m - v\,;\; Q = m + v\,;\; Q = {}^{v}\!/_{m}\,;\; Q = m.v\,.$$

Then, discuss with the students which of these expressions is appropriate to describe the physical phenomenon under study.

Ask the students to work in groups and observe the following figure, talk to their partners and develop an explanation for the phenomenon that emerges from the observation. The person positioned the boat perpendicular to the dock and then disembarked. Will he achieve his goal?

If the students have difficulty establishing relationships between the observed facts, the teacher can introduce elements that can help the student structure his or her thinking, such as suggesting that the positive sign be attributed to the person's movement and the negative sign to the boat's movement. Do not lose sight of the ineffectiveness of cognitive conflicts according to Gil-Pérez et al (1999b) and work with the students' ideas as hypotheses that are replaced by others.

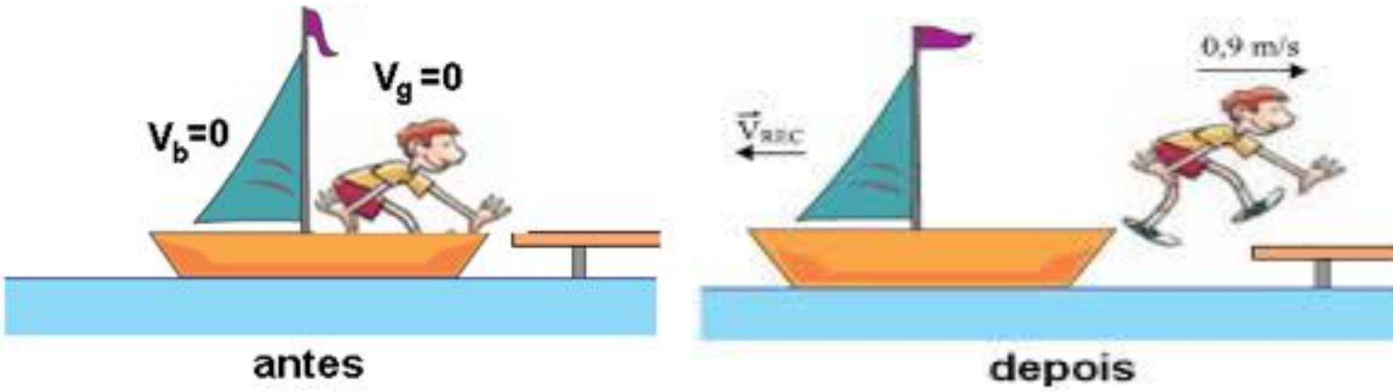

Figure 7: Will the person be able to achieve what they intended? Why?

Source: www.fisicaevestibular.com.br

Next, the teacher suggests that the students set up and carry out the following experiments with materials previously requested and prepared by the students. Ask each group to provide a plausible explanation for the facts observed. Encourage the students to propose a mathematical formulation for the concept of conservation of momentum.

a) Material: small, light wooden clipboard, measuring approximately 15cm x 20cm; rubber band to tie money; three small nails; two or more cylindrical pencils, small piece of paper to serve as a projectile and a match.

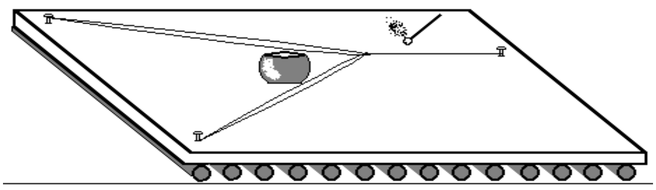

Figure 8 – Slingshot

Source: www2.fc.unesp.br

b) material: soda straw and balloon (first apparatus); small jar (photographic film packaging), string or fishing line, baking soda and vinegar (second experiment).

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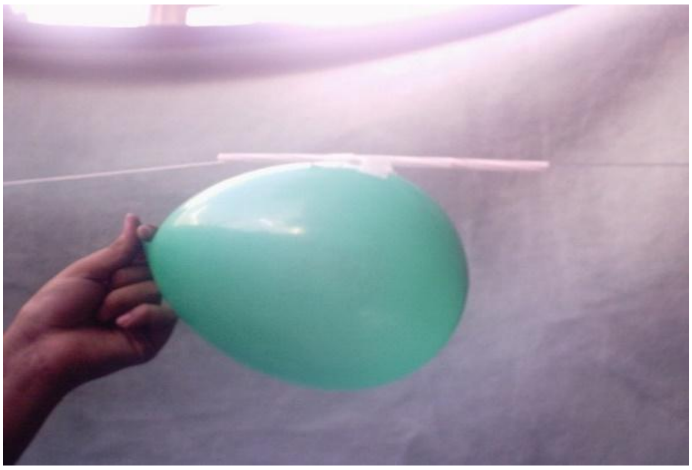

Figure 9: Why does the direction of movement of the ejected air have the opposite direction to that of the balloon?

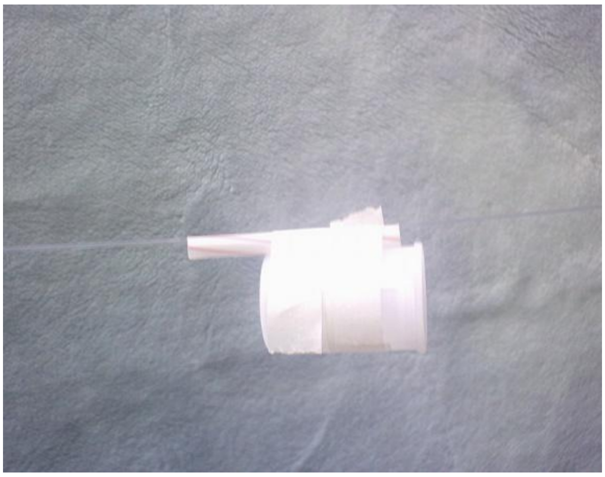

Figure 10: Baking soda. If water were used inside the jar instead of vinegar, would the same volume of gas be released in the chemical reaction? What significance do you attribute to the fact that the lid of the jar moves in the opposite direction to the jar after the “explosion”? Fonte: acervo próprio

Figure 11: A small cannon mounted on a cart. Made with a small plastic film container, wire, wood and plastic glue. By smearing the walls and bottom of the container with alcohol and fitting it onto the lid, the explosion will occur by pressing the lighter detonator.

c) material: two 2.5 m pieces of flexible hose, inside which PVC tubes, each measuring 1 m in length, should be inserted. The two hoses should be joined together with screws or superbonder glue to form a gutter. Leave 0.5 cm left in the central part to ensure the flexibility of the apparatus. Position the apparatus so that it has a horizontal part, articulated with an inclined part, as shown in the illustration. In the horizontal part, place one, two or three spheres, made of glass, metal or a snooker ball. At one point in the inclined part, shake a sphere and observe the collision with the horizontal part. Discuss with the students the existence of something that is transmitted and preserved.

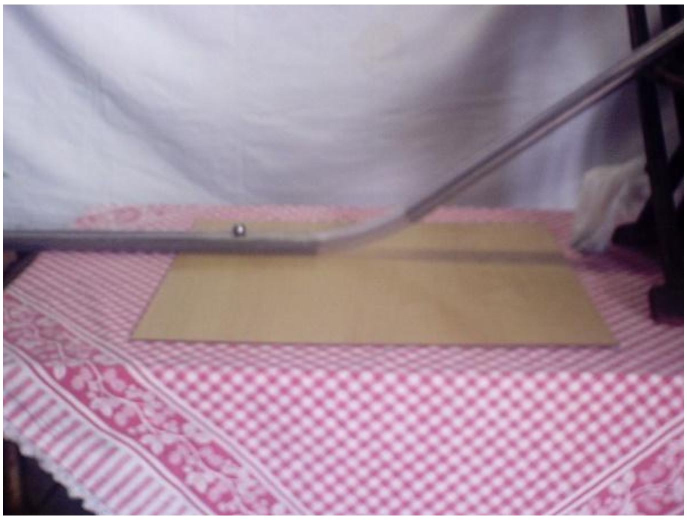

Figure 12: collision between spheres in a channel made with flexible hose. Is there something that is transferred and preserved?

d) Newton pendulum. Material: metal or glass spheres or snooker ball, string or fishing line, superbonder glue and support for the suspended spheres. Assemble the apparatus so that it looks like this:

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Figure 13:– Apparatus built with steel balls, fishing line, wood, barbecue skewers (to support the suspended balls), superbonder glue and caulk.

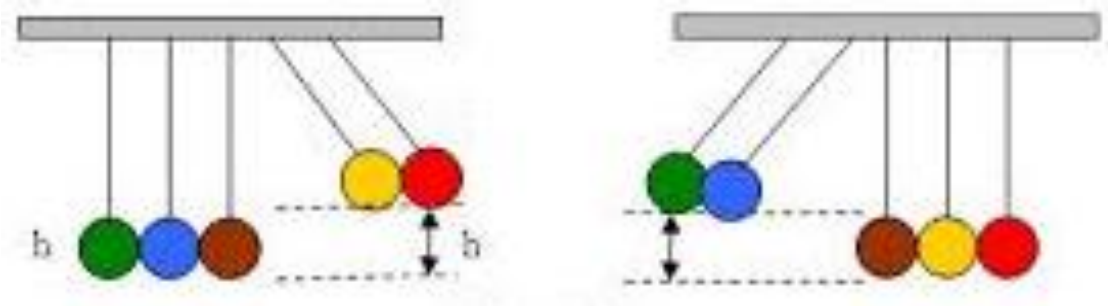

Figure 14. multiple pendulums colliding

(Source: portaldoprofessor.mec.gov.br)

The red and yellow spheres were moved away from their equilibrium position and abandoned. What phenomenon do you observe when these spheres collide with the others? Why does this happen?

4.6 Organization of knowledge: in search of light for structuring thought

We believe that instead of presenting in a dogmatic way the expression that best defines the Quantity of movement and its conservation, students could be provided with texts on the history of science, appropriate to the cognitive level of the class, which report events related to the topic, faithfully portraying the context of the time. The teacher's mediation would consist of helping students interpret texts and translate textual language into mathematical language.

4.6.1A historical view of momentum and its conservation

- Philosophical concepts that guided the development of the concept of momentum and its conservation.
- Scientists and thinkers who contributed to the formulation of this idea.
- Mathematical formulation of the concept of momentum and its conservation.

4.7 Application of knowledge

At this stage, groups of students may be asked to share their conclusions using posters, banners or slides (multimedia, projector or other means). A report must be presented at the end of the work, which will allow the teacher to assess whether the students have acquired the desired scientific knowledge.

In order not to limit themselves to just one assessment tool, the teacher may also use a written test, according to criteria previously agreed upon with the school's teaching and administrative team. It is important that the assessment provides support for the teacher to reflect on his/her performance and reassess his/her methodologies

5. FINAL CONSIDERATIONS

A purely historical approach to the content alone does not guarantee that the student will be motivated to study the proposed topic. According to Delizoicov *apud* Ricardo (2010), it is necessary to construct a problem situation that has the potential to provoke in the student the need to acquire knowledge that he or she does not yet have and that has not yet been worked on by the teacher. The proposed situation to be problematized is the occurrence of a traffic accident, a topic that is very present in the student's daily life, whether as a direct observer or through the media.

To solve the problems raised, Ricardo (2010) suggests that it is necessary to master specific content, the theme of which is quantity of movement and its conservation, which is achieved through the organization of knowledge. At this stage, the study of history texts related to the topic is proposed, combined with research in the textbook adopted by the school. In the knowledge application stage, by sharing the results of their research, the student has the opportunity to present a body of knowledge that is not compartmentalized, but rather woven into the unity of the various aspects of human life: social, political, economic, and religious. The knowledge acquired in this way is full of meaning for the

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student insofar as it is constructed from their experience with the world in which they live.

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