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# MANUAL FOR THE APPLICATION OF A TEACHING SEQUENCE ON ENERGY: SOME FORMS AND CONVERSION

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**Abstract**: This document contemplates a potentially significant teaching proposal for the teaching of energy, focusing on mechanical energy and its transformation into electrical energy. As a complement, the discussion of the conversion of thermal energy into electrical energy is envisaged. The proposal foresees six meetings with Second Year Regular High School students. In these meetings, using theoretical assumptions in the teaching-learning process, it is intended to make the student the main agent and active subject of all activities. The meetings encompass a series of activities, including experimental and computational ones for the desired purpose. The learning theories in question are Meaningful Learning, the Science, Technology and Society (CTS) approach and Information and Communication Technologies (ICT's).
**Keywords**: 1. Teaching Physics. 2. Meaningful Learning. 3. Energy. 4. Intellectual production.

## INTRODUCTION

This article is the result of Oliveira Junior's dissertation (2019), which discusses the teaching of Physics, particularly the concept of energy, focusing on mechanical energy and its transformation into electrical energy, as well as the conversion of thermal energy to electrical energy. In this product the teaching of this topic is based on the potentially significant teaching principles studied by Ausubel(1982). In order to carry it out, some of the Information and Communication Technologies (ICT's) such as Mello and Oliveira (2015) are included, which emphasize the importance of their insertion in schools. Therefore, this document constitutes a manual that can be used by Physics teachers with the mindset of helping them to plan their classes and optimize their preparation time, aiming to help the student to think critically about the topics covered., as stated by Bulgraen (2010).

This document represents a manual that can be used by Physics teachers to help them plan their classes and optimize their preparation time. It is also designed for the student to become active in the teaching-learning process and for the teacher to mediate situations in which the student is provoked to think critically about the topics discussed, as stated by Bulgraen (2010). Thus, the educational product in question is intended to be followed so that students stop thinking that Physics is an obstacle in their student life.

## METHODOLOGY

This chapter is based on a proposal for a class on the energy theme where the objective is to make the student stand as the protagonist of the teaching-learning process, so the choice was made from assumptions based on meaningful learning where ICTs are used as a tool to help teachers, as they allow establishing the student as a central concern in the teaching-learning process, leaving the teacher's role only as a mediator, seeking new teaching strategies aimed at the relationship between the content given in the classroom and the daily life of the students, thus, a motivational process begins so that the classes are more attractive and have a positive return. Allied to this, the energy theme was perceived as a subject that has several uses in the lives of students and at the same time is inserted in the school curriculum, especially in the discussion about alternative sources of energy in order to preserve the environment.

The target audience is regular Second Year High School classes of the State Public Education Network.

It is intended to present a set of six meetings, in which the concepts of energy will be presented on a theme that will make the student realize his main role in the teaching-learning process. Such meetings are inspired by Ausubel 's ideas, which with his theory of Meaningful Learning will make the student connect his initial ideas with what he will learn so that the absorption of knowledge takes place, and in some moments technology enters so that this follows the evolution of the contemporary world and also a little of the presence of experimentation so that the student's ability to solve problems in a theme that will involve his role as a citizen is required.

Target audience: 2nd grade or 3rd grade high school students.

Duration of classes: 2 periods of 50 minutes corresponding to each meeting.

1st meeting:

In the first contact with the students, the teacher, with his resourcefulness, needs to make the students feel comfortable and make it clear that at this moment, quantitative aspects will not participate in his analysis, in order to have the ability to introduce a survey about what they know. or not on the energy issue. This can be done through simple questions that will trigger a diagnosis of the class in which the teacher wants to apply such a product.

Next, even as a way of facilitating the analysis of the answers given by the class, the teacher to start the discussion on the topic can make the students answer the questions initially asked orally and, therefore, make them think best. In order not to get lost, it is interesting for the teacher to write down on the board (blackboard) the answers that call for better attention in order to connect them according to their daily lives. Still as a strategy to help the teacher, you can also ask your students to form small groups to think and debate on the proposed topic.

In the continuation of the meeting, the teacher must ask his students to read a text about energy in order to contextualize the theme and thus apply the knowledge in a more constructive and less mechanical way. According to Moraes (2008), it is extremely necessary within the teaching-learning process strategies that make students connect what is being discussed with the teacher with the context in which they are inserted, and this author ratifies this through the following statement:

> The mediation of learning must interconnect the subjects, exploring and facilitating the understanding of the world and its interactions. It has a fundamental character, so that meaningful learning can occur, a contextualized teaching of Physics in an interrelated way, reflecting on the social and cultural context. (MORAES, 2008).

Such activity must last about 40 minutes.

Then, the teacher, with the objective of motivating students to research correctly through a simple test, guided the students to describe the procedures they would do to research a topic using a computer present in the classroom. In turn, to research on the topic chosen by his students, the professor will use more academic resources such as websites of the main universities in the country (USP, UFRJ, UNICAMP, etc...), research bases for articles such as scielo. org, and also Google tools (Google Academic), comparing them with simple searches like "Yahoo answer", "Brasil Escola" and the Google website. Therefore, it will ask students to give their opinion about reliability. With this action, the teacher uses 30 minutes of his class.

At the end of the meeting, to serve as an ignition for the next class, the teacher can ask students to research on the topic of energy sources.

2nd date -

In this meeting, you can start it through a debate in which the advantages and disadvantages of the main energy sources used in the contemporary world will be questioned. The reason for this action is to contextualize and make this topic palpable for the student and place him/her as the protagonist in the decision to use energy sources in his/her life.

An example of an approach regarding the

main energy sources is according to figures 1, 2 and 3.

Next, in order to contextualize the connection between the physical quantity Velocity and Energy, a short video about the Kinetic Energy Recovery Systems (KERS) is used.found on youtube**,** as a strategy to bring this subject to the student by holding a conversation about Formula 1.

With the student more comfortable with the class, so that at the end of the process the teacher compares what was learned about the class, a small text can be used that encourages thinking about the topic of the video and the connection regarding the magnitudes seen in the classroom.

From there, the teacher can start the description about the kinetic energy, where the participation of the students in the description of the connectivity between the strategies used will make the topic be absorbed by the students more easily.

In the end, always encourage students to carry out research through websites with credibility regarding the topic that was studied, so that in the next class, what is not clear to the student can be a source of debates for the next meetings.

3 [the] date

At the beginning of the class, in order to show the usefulness of learning about what will be the focus of the class, the teacher will show a youtube video about the operation of a hydroelectric plant in which the student will perceive the presence of this type of energy. in your daily life.

Soon after the use of a text that shows how the structure of a hydroelectric plant is and its usefulness to make the student begin to perceive the emergence of a type of energy related to the waterfall.

Next, with the student already acclimated to the learning process proposed by the teacher, the discussion about gravitational potential energy can be started.

4th date -

At the first moment of the class, the teacher presents the PHET simulator to the class, which will serve as a visualization and manipulation instrument for students to understand the conversions of kinetic and potential energy. The intention at this point is to instruct students in the handling of the simulator.

The teacher for the application of this activity will need a place where computers will need to be made available and not forgetting that there is internet in that place. If this is not possible, an alternative that the teacher can create is through *Google Classroom*which presents students with a long list of advantages for students, noting that the advantage of the website (application) is that "students and teachers connect easily, inside and outside schools" (GOOGLE CLASSROOM, 2018). The purpose is to create a virtual environment for the class and from there already address the simulator page, and regarding the obstacle in relation to the provision of internet on site, the teacher can, through his smartphone, route internet to the class.

Soon after, with the student already familiarized with the simulator, the teacher, in order to diagnose the students' understanding of the aforementioned conversion processes, will be able to distribute a questionnaire. If computers are not available for all students on site, the activity can be done in groups. The entire activity can be completed in 1 hour and 40 minutes.

5th date -

Here, the teacher can start his class by debating with his students about the concept of Mechanical Energy, with the objective of making the student have the perception of understanding the forms of energy present in different situations. (estimated time - 20 minutes)

| Fonte Não-renovável | Obtenção | Uso | Vantagens | Desvantagens |
|---|---|---|---|---|
| **Petróleo** | Resulta de reações químicas em fósseis depositados principalmente no fundo do mar. É extraído de reservas marítimas ou continentais | Produção de energia elétrica; matéria-prima da gasolina, do diesel e de produtos como o plástico, borracha sintética, cera, tinta, gás e asfalto. | Domínio da tecnologia para sua exploração e refino; facilidade de transporte e distribuição. | polui a atmosfera com a liberação de dióxido de carbono, colaborando para o efeito estufa. |
| **Nuclear** | Reatores nucleares produzem energia térmica por fissão (quebra) de átomos de urânio. Essa energia aciona um gerador elétrico. | Produção de energia elétrica; fabricação de bomba atômica. | A usina pode ser instalada em locais próximos de centros de consumo; não emite poluentes que contribuam para o efeito estufa. | Não é tecnologia para tratar lixo nuclear; a construção de usinas é cara e demorada; existe risco de contaminação nuclear. |
| **Carvão mineral** | Resulta da transformação química de grandes florestas soterradas. É extraído de minas localizadas em bacias sedimentares. | Produção de energia elétrica; aquecimento, matéria-prima de fertilizante. | Domínio de tecnologia para seu aproveitamento; facilidade de transporte e distribuição. | Libera poluentes como dióxido de carbono e óxidos de nitrogênio; contribui para a chuva ácida. |

Figure 1 – Center for Applied Research and Teaching (CEPA) belonging to the Physics Institute of the University of São Paulo (IF-USP). Comparative table between advantages and disadvantages of energy sources. Available at: <http://www.cepa.if.usp.br/energia/energia1999/Grupo2B/Hidraulica/energia_recurso.htm >. Accessed on 20 Sep. 2017.

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|---|---|---|---|---|
| **Gás natural** | Ocorre na natureza associado ou não ao petróleo. A pressão existente nas reservas impulsiona o gás para a superfície, onde é coletado em tubulações. | Aquecimento; combustível para geração de eletricidade, veículos, caldeiras e fornos; matéria-prima de derivados da indústria petroquímica. | Não emite poluentes; pode ser utilizado nas formas gasosa e líquida; existe grande número de reservas. | A construção de gasodutos e metaneiros (navios especiais) para o transporte e a distribuição requer alto investimento. |
| Renovável **hidre-letricidade** | A energia liberada pela queda de água represada move uma turbina que aciona um gerador elétrico. | Produção de energia elétrica. | Não emite poluentes; a produção é controlada; não interfere no efeito estufa. | Inundação de grandes áreas e deslocamento de população residente; a construção das usinas é cara e demorada. |
| **Eólica** | O movimento dos ventos é captado por pás de hélices gigantes ligadas a uma turbina que acionam um gerador elétrico. | Produção de energia elétrica; movimentação de moinhos. | Grande potencial para geração de energia elétrica; não interfere no efeito estufa; não ocupa áreas de produção de alimentos. | Exige investimentos para a transmissão da energia; produz poluição sonora; interfere em transmissões de rádio e TV. |
| **Solar** | Lâminas recobertas com material semicondutor, como o silício, são expostas ao Sol. A luz excita os elétrons do silício, que formam uma corrente elétrica. | Produção de energia elétrica; aquecimento. | Não é poluente; não interfere no efeito estufa; não precisa de turbinas nem geradores para a produção da energia elétrica. | Exige alto investimento para o seu aproveitamento. |

Figure 2 - Center for Applied Research and Teaching (CEPA) belonging to the Physics Institute of the University of São Paulo (IF-USP). Comparative table between advantages and disadvantages of energy sources. Available at: <http://www.cepa.if.usp.br/energia/energia1999/Grupo2B/Hidraulica/energia_recurso.htm >. Accessed on 20 Sep. 2017.

| | | | | |
|---|---|---|---|---|
| **Biomassa** | A matéria orgânica é decomposta em caldeira ou biodigestor. O processo gera gás e vapor, que acionam uma turbina e movem um gerador elétrico. | Aquecimento; produção d energia elétrica e de biogás (metano). | Não interfere no efeito estufa (o gás carbônico liberado durante a queima é absorvido depois no ciclo de produção). | Exige alto investimento em seu aproveitamento |

Figure 3 - Center for Applied Research and Teaching (CEPA) belonging to the Physics Institute of the University of São Paulo (IF-USP). Comparative table between advantages and disadvantages of energy sources. Available at: <http://www.cepa.if.usp.br/energia/energia1999/Grupo2B/Hidraulica/energia_recurso.htm >. Accessed on 20 Sep. 2017.

Next, the teacher will consider special situations, where there are no resistances, in which case the conservation of mechanical energy comes in and to show this situation in a practical way, the simulator used in the previous meeting comes in. (estimated time – 20 minutes)

Now, the professor will discuss energy transformation, using the conversion of thermal energy into electrical energy. For this, he provides a small text on thermoelectricity and the Seebeck effect as a reference for alternative energy for the present day. The purpose of this action is to assess students' first impressions of the subject. (estimated time – 10 minutes)

After reading the text, the teacher can start a discussion about this way of obtaining energy and leaving students as protagonists of this action where, whenever possible, make them think about why they are not currently obtaining energy for the operation of electrical devices. in our homes. (estimated time – 50 minutes)

At the end of the meeting, the teacher must ask the students to do a little research on electric current and potential difference in order to get used to concepts that will be addressed in the next meeting.

6th date -

At the beginning, the teacher must take his students, if possible, to an adequate space for carrying out experiments (laboratory). Here, students are instructed on how to handle a multimeter (the teacher will need such an instrument for this activity) and reinforce the idea regarding the concepts of electric current and potential difference. (estimated time – 20 minutes)

Next, the teacher will provide "alligator" wires and different metals arranged so that students in groups of a maximum of 5 people follow instructions and raise their students' analysis of the procedure (estimated time – 1 hour and 10 minutes).

At the end of the meeting, the teacher, based on the youtube video about generating energy with water, must show a more efficient way of obtaining electricity through the Seebeck effect, using a Peltier plate glued between two cans where hot water is poured into each one. and cold and then connecting alligator clips to the wires on the board to connect them to the multimeter, so that it records the voltage. The function is to let the student question the reason for this improvement and, acting as a mediator of the process, show the role of the Peltier plate in this phenomenon. Of course, depending on the level of your class, the teacher can have a deeper debate about the role of the semiconductors present in the Peltier plate in improving the conversion of thermal energy into electrical energy (estimated time – 20 minutes).

## APPLICATION

The application of the educational product took place at Colégio Estadual Presidente Kennedy, in the city of Belford Roxo, in the State of Rio de Janeiro. The product was applied to a class of 29 adolescents from the Second Year of Regular High School in classes lasting one hour and forty minutes.

The first class begins with the delivery of a questionnaire (present in Appendix B as a questionnaire - survey of previous knowledge) with the objective of capturing students' previous knowledge about the energy topic, as illustrated in figures 4 and 5. The time used in this activity was approximately 30 minutes.

Their answers regarding what energy is and based on electricity and performing tasks. Regarding the types of energy, the vast majority described electric, solar, wind and hydraulic correctly relating them to their uses in their daily lives.

For Moreira (2015), the presence of previous organizers is the plan developed by Ausubel

(1982) to handle the cognitive structure of students in order to be a facilitating agent in the teaching-learning process. They are materials to be introduced before the content to be worked on and serve as a link between what the student already knows and what he must learn, so that at the end of the process it is absorbed in a meaningful way.

In the following moment, an initial debate began on the energy theme and, as the mediator of the process, I placed their reports on the board, as shown in Figure 10. This debate lasted about twenty minutes.

This is presented by Moreira (2015) when he refers to the cognitive structure of students requiring interactions so that information can proceed and help them to fit into the organization and integration. It is the starting point for the entry of the so-called subsumers, which serve as a key reference for triggering the ideas addressed by the students on the subject. It is essential to create strategies that aim to influence the emergence of these elements.

For Arruda et al. (2004) in the ideas of Ausubel, meaningful learning is understood as a process in which new information is absorbed as it is related to congruent thoughts already existing in the student's cognitive structure, that is, it is the ignition point of the connection of what the student already knows and the new information acquired by him. The so-called subsumers that related to the new concepts worked by the teacher form a connection in order to give meaning.

Moreira (2015) also warns of the care that teachers need to take in making the process one of memorization where the learning of new information does not present any or little interaction with concepts present in the students' cognitive structures.

For Praia (2000), the foundation of Ausubel 's theory is that learning must be meaningful, that is, the subject learns and will possibly learn when new knowledge is linked to their already acquired knowledge. The teacher's role here is to identify what the student already knows.

Continuing the class, the students were asked to divide themselves into groups of three people so that they could discuss this topic, as illustrated in Figure 7. To help them in this activity, I distributed a small text that can be found on Eletronuclear's official website. The time used in this process was approximately fifty minutes.

At the end of the first class, with the purpose of comparing websites on school subjects, students were induced to search for texts related to the subject of energy sources, having as a reference web pages from more reliable sources such as: *USP, UFRJ, SBF, CBPF* among others (figure 8). This mentioned stimulus occurred through the use of my computer in the classroom and making comparisons between search sites in which students in their daily lives tend to search for information about topics not only related to science and discussing credibility. It was quite enriching, as reports such as: *"there really is a lot more information on these sites that you are showing", "That's why our teachers take points from us, now I just go to these sites and use this academic google".*

At the beginning of the second class, a debate took place with the intention of discussing the topic of energy sources. The reference for the action was a comparative table between the various energy sources used in the world found (figure 9) on the USP website, as it made clear the advantages and disadvantages of each use of the type of energy, allowing the description of use, obtaining and of Brazil's role in obtaining each source. I believe it was one of the most participatory moments for the students with questions like: *Why isn't solar energy used in all homes? Can we blow up the world using nuclear energy? When I go to my*

Figure 4 - Student answering the questionnaire to obtain prior knowledge.

Figure 5. - Student involved in answering the questionnaire to capture her previous knowledge.

Figure 6 - Student reports about what they have heard about energy.

Figure 7 - Groups of 3 students involved in the text for their discussion

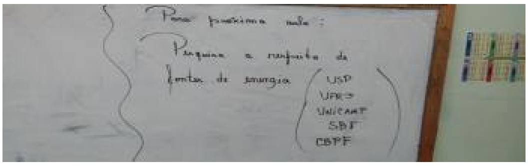


Figure 8 - Instruction for the Research Task on the topic of Energy Sources.

*family's house in Ceará, I see propellers on the beaches like a fan, what are they for?*

The time spent on this activity was about thirty minutes.

In the following moment, a video (figure 16) was seen on youtube in order to explain the operation of the **Kinetic Energy Recovery Systems,** which has the acronym KERS, and to be a starting point for the introduction of the subject. kinetic energy.

Soon after that moment, a text was distributed to the class to help students understand the operation of this device, accompanied by small questions (figure 13) that had the function of helping the teacher to continue the class. The time for this procedure was forty minutes.

It was noticed in the answers to the text that most of the class already knew about kinetic energy, as they correctly related it to the functioning of KERS. With respect to all forms of energy involved in the operation of KERS, heat, thermal, electrical and kinetic energy emerged.

Next, the concept of *kinetic energy was introduced in the class* (figure 14), correlating with the video and also with the text, thus, giving meaning to the importance of such type of energy as the protagonist of the process. With that I was able to make clear to the students its qualitative and quantitative connection with the physical quantity *velocity.* The time of this action was approximately thirty minutes.

In the next class, he started with a short video about the operation of a hydroelectric plant (figure 15). The time taken for this action was approximately ten minutes. And later, a text was delivered to start a brief reading on the topic of the video, in order to collect the understanding of the students. Time used at that time was approximately forty minutes.

Regarding the question that associated the type of energy stored in the dams of the hydroelectric plant, the answers were divided into kinetic energy (which may be influenced by the previous class) and potential and kinetic energy. The question associated with the energy acquired by the water in its fall was also divided between the answers in which mechanical energy and kinetic energy prevailed and the question related to the form of energy that reaches their homes was unanimously answered by electrical energy. This moment was important, because the students' perception of the occurrence of energy transformation from one form to another took place.

At the last moment of the class, the type of energy called *gravitational potential energy was approached,* relating it to the video and the text through the debate on the question of the role of dams and waterfalls, these being the strategies used to qualitatively associate *the role of height and amount of water (mass),* in relation to the location, we compared some places such as: Earth and Moon so that we can deductively compare the time it takes for water to fall and relate it to energy. Another approach was to associate *work* with physical magnitude,that had previously been worked on,in order to make clear their participation in the process. Through this opening, the quantitative form of *gravitational potential energy* was worked out with the direct relationships with these associated quantities.

According to Moreira (2015), meaningful learning is analogous to verbal learning, as Ausubel took into account the importance of language as a tool to facilitate the process. The association of concepts is significantly amplified by the properties that words have to represent everything that is proposed. Language provides the starting point for the entry of meaning, making it easier to show. The duration of this activity was fifty minutes.

In the following class, the PHET simulator was presented (figure 16) and guided on how

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| Renovável **hidre-letricidade** | A energia liberada pela queda de água represada move uma turbina que aciona um gerador elétrico. | Produção de energia elétrica. | Não emite poluentes; a produção é controlada; não interfere no efeito estufa. | Inundação de grandes áreas e deslocamento de população residente; a construção das usinas é cara e demorada. |
| **Eólica** | O movimento dos ventos é captado por pás de hélices gigantes ligadas a uma turbina que acionam um gerador elétrico. | Produção de energia elétrica; movimentação de moinhos. | Grande potencial para geração de energia elétrica; não interfere no efeito estufa; não ocupa áreas de produção de alimentos. | Exige investimentos para a transmissão da energia; produz poluição sonora; interfere em transmissões de rádio e TV. |
| **Solar** | Lâminas recobertas com material semicondutor, como o silício, são expostas ao Sol. A luz excita os elétrons do silício, que formam uma corrente elétrica. | Produção de energia elétrica; aquecimento. | Não é poluente; não interfere no efeito estufa; não precisa de turbinas nem geradores para a produção da energia elétrica. | Exige alto investimento para o seu aproveitamento. |

Figure 9 -Center for Applied Research and Teaching (CEPA) belonging to the Physics Institute of the University of São Paulo (IF-USP). Descriptions of the main energy sources. Available at: <http://www.cepa.if.usp.br/energia/energia1999/Grupo2B/Hidraulica/energia_recurso.htm >Accessed on 20 Sep. 2017.

Figure 10 - Debate on the topic of Energy Sources.

Figure 11 - Discussion about the advantages and disadvantages of the main Energy Sources.

Figure 12 - Video showing how KERS works.

Figure 13 - Student reading the text about how KERS works.

Figure 14 - Presentation of the kinetic energy theme

Figure 15 - Video display on hydropower.

to use it. Each student was free to handle it for a moment so that they could adapt to the process. The strategy at that time was another means that was planned so that students could not only visualize the process, but also participate as active subjects in learning. Of course, for this to happen, some challenges had to be overcome, such as the acceptance of the students and the school, the preparation to mediate the tool and if the students would practice the activity correctly. This is described by Soares-Leite and Nascimento Ribeiro (2012) when they state that for the inclusion of Information and Communication Technologies (ICT'S) in education in a satisfactory way, a set of factors is necessary, among the most important, the teacher's domain about technological tools and their handling in practice, that the school is prepared for such entry, that is, its structure has the responsibility of enabling students to have access to such tools during classes, that the teacher has the mentality of the importance of their constant updating, as the contemporary world makes it present in the face of the emergence of new techniques and approaches in the teaching-learning process and not forgetting the connection that the curriculum needs to present for the introduction of these technologies.

According to Vaniel et al (2011), the introduction of ICTs in Physics teaching can be very effective, as it has several challenges, and among them it is worth highlighting the small interest and great learning difficulty of the students, creating a some dissatisfaction on the part of teachers about how digital technologies connected with pedagogical practices can contribute to the success of teaching. There is a need for the school to modernize its classes and update the pedagogical instruments. A recommendation would be the use of animations and simulations, as they are resources that aid in learning and can serve as a reference in motivating students. The duration of this instruction was about twenty minutes.

From that moment on, a questionnaire was delivered, where a group of four or five students answered it and used the simulator itself to understand the conversions of gravitational and kinetic energy. The *Google Classroom* mobile application was used as a fundamental tool for the activity, since the school did not have an internet network on its computers. A cell phone served as a router so that the students' cell phones had access to the internet (Figure 17). The time spent on this task was one hour and twenty minutes.

In the first part of the questionnaire without the presence of friction, almost all the class correctly answered the energy transformations suffered by the skater. Regarding whether to leave the ramp or not, the answers were divided in relation to not leaving the ramp, justifying that the energies are at the "same level", that the increase in speed was always the same and also because in the simulation this was not was visualized. And on the issue associated with the influence of mass, the group was unanimous in affirming a change in the movement by realizing the speed in the increase of the mass and the slowness in the decrease, but they also realized the direct relationship of this magnitude with the energy.

In the second part, when friction was added, the class realized the influence of thermal energy on the movement and its relationship with the skater's stop. In the question related to the increase and decrease of friction, they also noticed the variation of thermal energy in the process.

At the end of the class, I asked them to carry out a research on electric current and potential difference based on support texts for the Physics professor at the Federal University of Rio Grande do Sul (UFRGS), published in 2014 (LARA, 2014) regarding the pages 13 to

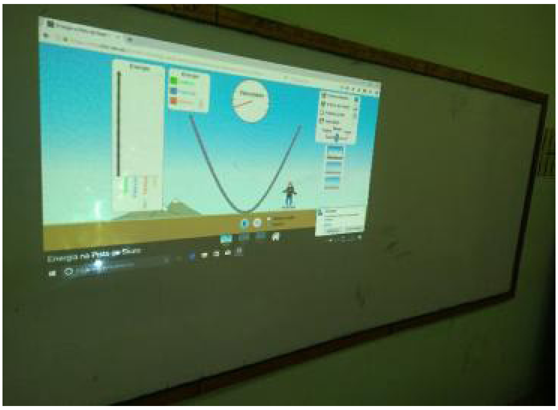

Figure 16 - PHET simulator instruction.

Figura 17 - Students taking the quiz and handling the PHET simulator.

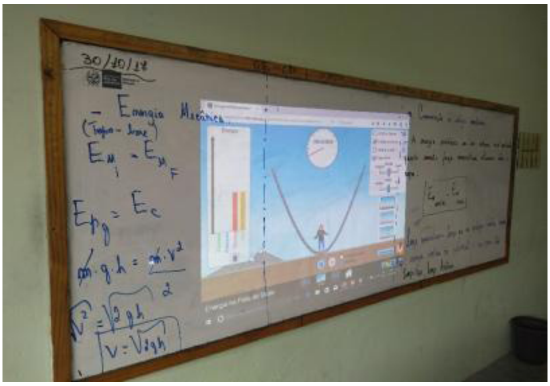

Figure 18 - Approach to Mechanical Energy Conservation.

Figure 19 - Teacher putting ice water on the students' bench.


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Figure 20 - Students reproducing the Seebeck effect.

Figure 21 - Students reproducing the Seebeck effect.

Figure 22 - Teacher showing a better way of capturing electrical energy through the Seebeck effect.

19.

In the next class, initially there was a discussion about *mechanical energy* using simulation as a reference in this approach (figure 18), as we talked about energy conversions that were used qualitatively and quantitatively. The duration time interval was twenty minutes.

Next, the students received a text on *thermoelectricity* and the *Seebeck effect,* so that they could evaluate their first impressions on this topic.

The choice of this theme came from the idea of the need that society has to start thinking about alternative forms of energy to the one we have today and the great future potential that this form of energy can consolidate in Brazil. Equally it allows discussion of energy transformation from one form to another. According to Silva and Carvalho (2009), Science Teaching opens the possibility of discussing issues in which there is a relationship with various social and environmental implications of Science and Technology, although complex, but consolidating itself as a significant path with the objective of generating in the classroom the beginning of the construction of scientific knowledge. The duration of this reading was approximately ten minutes.

At the end of the class, we had a very enriching debate on the Seebeck effect, encouraging students to create alternatives for their use to improve the environment in which they live and as an alternative to in times of crisis. At that moment, we had questions from the students, such as: "*Why can't electricity come from this source*", "*So we don't need hydroelectric plants anymore, right*"? According to Silva and Carvalho (2009), we must address the risks and benefits of applying Science and Technology so that we can be able to make decisions to find better alternatives. The duration of this activity was one hour and ten minutes.

In the last class, we went to the science lab to qualitatively reproduce the *Seebeck effect*. In the first moment of this class, students were instructed how to handle a multimeter and reinforce the idea about *electric current* and *potential difference.*

According to Villani and Nascimento (2003) teachers and students need to be dialogically connected so that concepts such as laws, theories and principles present in school scientific knowledge make sense. Thus, language needs to be shared so that students, the main actors, can absorb school scientific knowledge from their classroom knowledge. School scientific knowledge is the result of processes of transposition of scientific knowledge evidenced in university textbooks and adapted to the reality of elementary and secondary science education. The time used in this moment of the class was approximately twenty minutes.

Continuing the class, the students received instructions on the activity to be performed to simulate the Seebeck effect (located in Appendix B as Summative Assessment - class 6) and thus demonstrate the possibility of performing it effectively. One of the procedures of such activity is to handle water with high and low temperature values, therefore, the care with the students' integrity is paramount at this time (figure 19). The experimentation carried out by the students is shown in figures 20 and 21. Time spent in this activity was approximately one hour.

After the students' participation, a slightly more complete experience was demonstrated through a Peltier plate, which according to Fernandes (2010) are also known as thermoelectric tablets, and use the cooling or heating effect by passing direct electric current through two conductors.. With a voltage applied between the poles, a temperature variation arises between opposite faces of the



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plate. This is connected through "alligator" clamps connected to a multimeter (figure 22) and stuck between two cans where water at different temperatures was placed, with the aim of showing an advance in the capture of electrical energy by the *Seebeck effect.*

Here, the highlight was the involvement of the students, where the groups disputed among themselves that they could obtain the highest voltage value and an appearance of electric current recorded by the multimeter, thus, their participation became contagious. Speeches such as: " *teacher, all your classes could be like this*", "*just watching you, the teacher, talk is very boring*" appear naturally and, therefore, there was also a certain reflection so that the classes could be improved.

In the experience that was shown, the students' acceptance was instantaneous as their perceptions about the great potential to improve the capture of electric energy made their questions and thoughts free. They realized that continuous evolution needs to happen, in order to be used on a large scale. The impact on the execution of the experiment was effective and expressions such as: *"damn, the teacher got an even greater value than ours". "All because of that little sign." "So we can come up with something even better and suddenly make things in my house work." "If I manage to improve this funding, I can earn a lot of money".*

At the end of the class, there was an emphasis on charging for the delivery of the activity that was applied, where a summative assessment was linked to the instruction of experimentation (which was worth 30% of the final grade) and intended to analyze the absorption of knowledge during the classes that resulted in the creation of the educational product. It took approximately twenty minutes.

Most of the students' answers had a great analysis of the phenomenon, where it was noticed that despite not remembering its name, they knew about the influence of the temperature difference and the presence of different metals for its production.

In the same week, however, on a day that did not coincide with the Physics class, another teacher was asked to apply another assessment (which was worth 50% of the grade), to diagnose the entire process.

## RESULTS

Before analyzing the results, the qualitative character is emphasized, because due to the complexity of the teaching-learning process, it is very difficult to say at first the effectiveness or not of the application of the educational product, but the most important thing is the initiative to change directions. that were being established with the continuity of the way that the classes affected the students, making them take a back seat.

The reference will be the summative assessment made by the students, which was worth 50% of their final grade for the bimester for contemplating the concepts covered in the activities of the application of the educational product.

The first question showed an everyday situation that was intended to make the students relate the increase in height with the respective increase in Gravitational Potential Energy. The problem was composed of 5 alternatives seen above and the answers were as follows:

- item a – 4 students marked it (corresponds to approximately 14% of the class).
- item b – 6 students marked it (corresponds to approximately 21% of the class).
- item c – 8 students marked it (corresponds to approximately 28% of the class).

Avaliação Somativa ( 5 pontos) – 2 ano

1. Arlindo é um trabalhador dedicado. Passa grande parte do tempo de seu dia subindo e descendo escadas, pois trabalha fazendo manutenção em edifícios, muitas vezes no alto.

Considere que, ao realizar um de seus serviços, ele tenha subido uma escada com velocidade escalar constante. Nesse movimento, pode-se afirmar que, em relação ao nível horizontal do solo, o centro de massa do corpo de Arlindo

a) perdeu energia cinética.
b) ganhou energia cinética.
c) perdeu energia potencial gravitacional.
d) ganhou energia potencial gravitacional.
e) perdeu energia mecânica.

2. Um saco de cimento de 50 kg está no alto de um prédio em construção a 30 m do solo.
Sabendo que a aceleração da gravidade local é de 10 $m/s^2$, podemos afirmar que a energia potencial do saco de cimento em relação ao solo, em joules, vale

a) 5 000.
b) 10 000.
c) 15 000.
d) 20 000.
e) 30 000.

3. Na construção das barragens das usinas hidrelétricas são utilizadas grandes quantidades de concreto.
Essas barragens têm como função represar a água para que esta adquira energia potencial.
No conjunto formado pela turbina e pelo gerador, ocorre a conversão de

a) energia potencial em energia elétrica.
b) energia térmica em energia cinética.
c) energia cinética em energia elétrica.
d) energia elétrica em energia potencial.
e) energia potencial em energia radiante.

Figure 23 – Summative assessment distributed to students.


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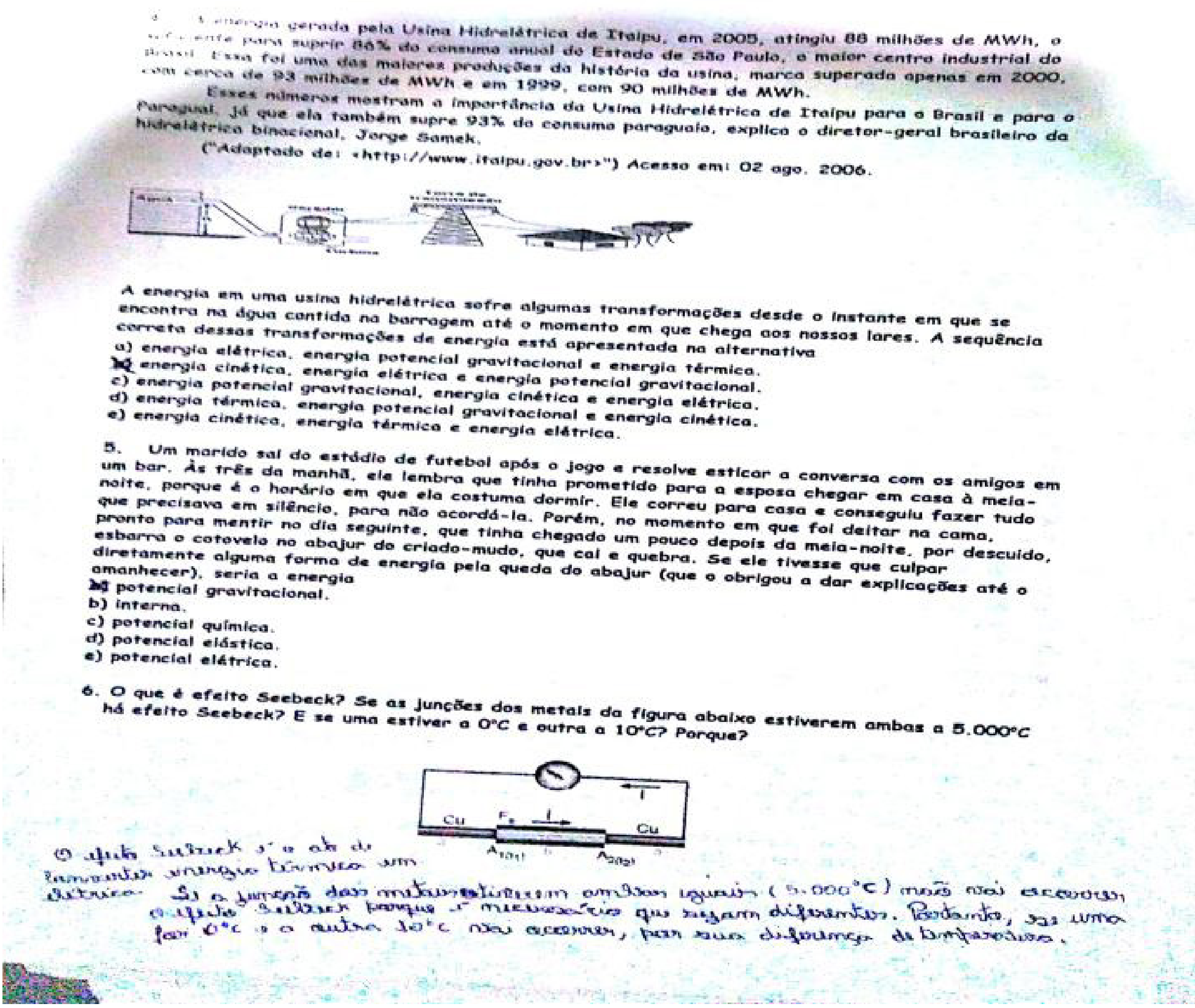

[illegible] A energia gerada pela Usina Hidrelétrica de Itaipu, em 2005, atingiu 88 milhões de MWh, o suficiente para suprir 86% do consumo anual do Estado de São Paulo, o maior centro industrial do Brasil. Essa foi uma das maiores produções da história da usina, marca superada apenas em 2000, com cerca de 93 milhões de MWh e em 1999, com 90 milhões de MWh.

Esses números mostram a importância da Usina Hidrelétrica de Itaipu para o Brasil e para o Paraguai. Já que ela também supre 93% do consumo paraguaio, explica o diretor-geral brasileiro da hidrelétrica binacional, Jorge Samek.

("Adaptado de: <http://www.itaipu.gov.br>") Acesso em: 02 ago. 2006.

A energia em uma usina hidrelétrica sofre algumas transformações desde o instante em que se encontra na água contida na barragem até o momento em que chega aos nossos lares. A sequência correta dessas transformações de energia está apresentada na alternativa

a) energia elétrica, energia potencial gravitacional e energia térmica.
b) energia cinética, energia elétrica e energia potencial gravitacional.
c) energia potencial gravitacional, energia cinética e energia elétrica.
d) energia térmica, energia potencial gravitacional e energia cinética.
e) energia cinética, energia térmica e energia elétrica.

5. Um marido sai do estádio de futebol após o jogo e resolve esticar a conversa com os amigos em um bar. Às três da manhã, ele lembra que tinha prometido para a esposa chegar em casa à meia-noite, porque é o horário em que ela costuma dormir. Ele correu para casa e conseguiu fazer tudo que precisava em silêncio, para não acordá-la. Porém, no momento em que foi deitar na cama, pronto para mentir no dia seguinte, que tinha chegado um pouco depois da meia-noite, por descuido, esbarra o cotovelo no abajur do criado-mudo, que cai e quebra. Se ele tivesse que culpar diretamente alguma forma de energia pela queda do abajur (que o obrigou a dar explicações até o amanhecer), seria a energia

a) potencial gravitacional.
b) interna.
c) potencial química.
d) potencial elástica.
e) potencial elétrica.

6. O que é efeito Seebeck? Se as junções dos metais da figura abaixo estiverem ambas a 5.000°C há efeito Seebeck? E se uma estiver a 0°C e outra a 10°C? Porque?



O efeito Seebeck é o ato de transformar energia térmica em elétrica. Se a junção dos metais estiverem ambas iguais (5.000°C) não vai acontecer o efeito Seebeck porque é necessário que sejam diferentes. Portanto, se uma for 0°C e a outra 10°C vai acontecer, por sua diferença de temperatura.

Figure 24 – Summative assessment distributed to students.


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- item d (correct) - 11 students marked it (corresponds to approximately 38% of the class)
- item e - no student checked.

The command of the problem required the student to perceive the fact that the speed was not changed and the height was increasing in relation to the adopted reference, but some students did not perceive this. It is not known whether due to lack of attention in reading or due to some delay in the teaching-learning process.

The second question addressed another common situation in which quantitative data were exposed so that the student is able to calculate Gravitational Potential Energy. The answers were as follows:

- item a – 5 students marked it (corresponds to approximately 17% of the class).
- item b – 2 students marked it (corresponds to approximately 7% of the class).
- item c (correct) – 19 students marked it (corresponds to approximately 65% of the class).
- item d – 1 student checked (corresponds to approximately 3% of the class).
- item e – 2 students marked it (corresponds to approximately 7% of the class).

This question was intended to make the student relate the quantities present in the calculation of Gravitational Potential Energy. It was noticed that most of the class got the problem right, but some students did not relate the height of the body to the situation.

The third question addressed the construction of dams in hydroelectric plants and spoke of its relationship with Gravitational Potential Energy. This question asked the students to relate the energy transformations that take place in the turbine and in the generator.

- item a – 9 students marked it (corresponds to approximately 31% of the class).
- item b – no student checked.
- item c (correct) – 8 students marked it (corresponds to approximately 28% of the class).
- item d - 12 students marked it (corresponds to approximately 41%)
- item e - no student checked.

This question drew attention due to the deficient physical interpretation of the situation shown by the fact that they did not correctly correlate the energy transformations that took place in the problem. Such a finding can be evaluated by some failure in the concept acquisition process or by a reading and interpretation deficiency.

In the fourth problem there was a small text about the importance of hydroelectric plants and asks the student to know about all the energy transformations that happen from the water accumulated in the dam to the moment it arrives at the homes.

- item a – 1 student checked (corresponds to approximately 3% of the class).
- item b – 12 students marked it (corresponds to approximately 41%).
- item c (correct) – 10 students marked it (corresponds to approximately 34%).
- item d – 1 student checked (corresponds to approximately 3%).
- item e - 5 students marked it (corresponds to approximately 17%).

This problem somewhat complemented the previous question in the requirement regarding the vision of energy transformations that occur in a hydroelectric plant. It is also possible to analyze from the prism of the previous question the misinterpretations, that is, there were errors in the learning process or in the reading of the situation.

The fifth problem contextualizes a daily situation in which he associated the fact with the action of Gravitational Potential Energy.

- item a (correct) – 23 students marked it (corresponds to approximately 79% of the class).
- item b – 1 student checked (corresponds to approximately 3% of the class).
- item c - no student marked
- item d – 1 student checked (corresponds to approximately 3% of the class).
- item e - 4 students marked it (corresponds to approximately 14% of the class).

This question was intended to find out if the student was involved in the activities, since the problem required relating height to the form of energy. It must also be emphasized that the alternatives of the problem helped the student a little in answering this problem since they were discussed in the classroom, so this fact may explain the high rate of correct answers.

The last problem addressed the experimentation carried out in the laboratory and was intended to obtain answers from the students regarding the Seebeck Effect phenomenon and also under what conditions such a phenomenon could happen or not.

- Regarding the concept of the Seebeck Effect – 9 students described it correctly (corresponds to about 31% of the class).
- About the emergence of the phenomenon – 13 students described it correctly (corresponds to about 45% of the class).

The problem showed that those students who did not answer correctly had a little understanding of the phenomenon, but at the time of transcription some deficiencies in the reading and writing were noticed, so the experimentation activity may still have been very beneficial in the teaching process - learning.

Considering the results described with the awareness of some problems related to reading and interpretation problems, it is concluded that there is a need for a reflection on the methods that were applied, since it was still perceived a little difficulty of the students in associating the contents addressed in their daily lives.

## CONCLUSION

Teachers need more attention in their work, as they face a lot of difficulties throughout their career. It is known about the educational crisis present in Brazil and this professional is undervalued in society. Therefore, the objective from the beginning of the work is to provide tools for it to be supported, as it does not have enough time to research academic reading and make its classes have more foundation.

The didactic sequence presented does not seek to be at any time something to be followed perfectly, the professor has total freedom to do what he wants and therefore, the main intention of the work is to stimulate the permanent updating of professors in their activities without ever forgetting to their concerns within the teaching-learning process, so that it is always kept in mind not only the ways to promote student protagonism, but also the construction of citizens aware of the problems that must be faced and solved by them in the future.

This work was guided by the development of a teaching sequence, involving Energy, focusing on Mechanical and Electrical Energy, and discussing energy conversions. It was applied in the classroom, which made it possible to verify its behavior in the field. It is intended to be part of a possible process of advancement in the country's educational situation through the implementation of new ways of teaching.

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