

**Analysis of an experience involving co-teaching in the context of the Pedagogical Residency Program, its impacts on teacher training and teaching development<sup>+</sup>**

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**Abstract**

*The present work presents the analysis of a teaching experience in physics teaching carried out in a high school located in the State of Rio de Janeiro. This model aims to promote dialogue between the actors involved in training and, in this way, foster both teachers' professional development and students' engagement. The activities were developed in the context of the Pedagogical Residency Program of the Physics Teacher Education Degree at Cefet -RJ Campus Petrópolis and involved pre-service Physics teachers, in-service Physics teachers in a partner elementary school and university lecturers. Emphasis was placed on a learning situation in which the relationship between teachers and their students in a co-teaching process, which was mediated by the use of an experimental model. The results point to the potential of co-teaching to promote changes in teaching processes, through the relationships of trust and respect established between subjects involved and, at the same time, to reveal aspects of the use of experiments as mediators in the teacher-student relationship, and to produce motivational effects, participation and engagement with the activity.*

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<sup>+</sup> Analysis of an experience involving Co-teaching in the context of the Pedagogical Residency Program, its impacts on teacher education and the development of teaching

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## **I. Introduction**

This work deals with the analysis of the educational potential of co-teaching, both for collaborative teachers and for basic education students, who participate in actions in the context of the internship and the Pedagogical Residency Program (PRP). Along with these aspects, we bring considerations about the use of experiments as mediating elements in the production of meaning, with respect to content learning as well as to aspects related to teacher-student interactions and students' engagement in the activity.

The events analyzed here are a small part of the activities developed under a PRP, whose actions were based upon co-teaching, a form of relationship between basic education schools and universities that seeks to build horizontal processes of collaboration between the different social actors of these institutions.

To build these relationships, co-teaching makes use of the work developed by preceptor teachers with their classes as a social context for bringing both university and school actors together. The involvement of these actors takes place in different dimensions of teaching work, namely, planning, teaching, evaluation and reflection. In the process, issues related to the professional development of preceptor, coordinator and resident teachers are also dealt with. Co-teaching considers teacher preparation in conjunction with students' learning in schools throughout the development of curricular work.

The data we analyzed are the result of the construction of didactic activities that were implemented by the residents together with the preceptors, in a co-teaching process, and were based on the physics curriculum for the 2nd grade of a secondary state school located in the center of Petrópolis, a city in mountain region of the state of Rio de Janeiro. The didactic sequence developed addressed the issue of electricity generation and sustainability and its construction took into account aspects present in the school curriculum, bringing elements of Paulo Freire's transformative education to the development of teaching strategies (GEHLEN; MALDANER; DELIZOICOV, 2012).

In this work, we show the structure of the activity developed by the residents, the preceptor teacher and the pre-service teacher, herein denominated resident, who worked collaboratively through co-teaching. Aspects of the reflexive dimension of this joint construction between university and school were addressed. In the dimension of professional training of residents, we deal with aspects of the relationship established between the preceptor teacher of the PRP and the resident while both were co-teaching. We investigated effects caused by the preceptor teacher's actions in the way the resident conducted the class, as well as the effects of these actions on the students' involvement with the activity. Together, we analyze the role played by the use of experimental models in the mediation between teachers and students.

The study is justified, therefore, by connecting aspects of professional training with curricular approaches to the topic of electricity generation and sustainability. It also emphasizes the need to break the limits of teaching models in which the teacher is only a lecturer. We believe that proposing debates, encouraging class participation, as well as direct involvement of students in building experiments can lead to a greater understanding of the topic studied.

The horizontal dialogue between the school and the university is seen as fundamental to the training process as it allows sharing experiences and knowledge produced in these different spaces, valuing the school and its teachers as producers of knowledge.

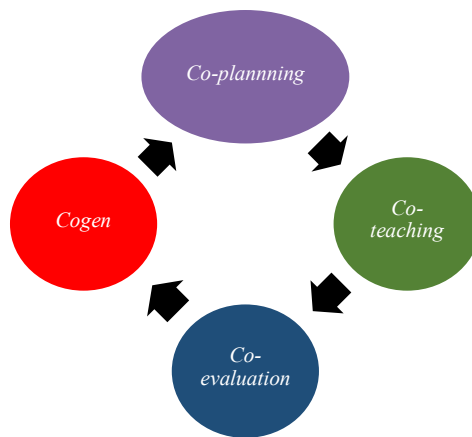
The objective of this research was to evaluate the implications of co-teaching in the construction of Physics teaching processes, which value dialogue and the construction of knowledge about the world, exploring its formative dimensions for basic education students and for other subjects participating in the process.

## **II. Co-teaching and horizontality in dialogues between professionals**

As Corrêa, Silva and Martins (2018) point out, the practice of internship must go beyond the emphasis on the instrumental dimension of teaching in order to promote critical reflection and collaboration between interns, school teachers, university teachers educators and other subjects involved in this training process. To this end, it is essential to deconstruct proposals and practices of repetition and mimicry of behaviors observed in the work of supervising teachers. It is about living experiences, trying out new roles that arise as a result of collective work and based on horizontality.

It is not just about the contact between professionals from university and schools, but about creating an environment of collaboration and trust in which it is possible to implement the co-teaching model. This model involves co-planning, co-teaching and co-reflecting (GALLO-FOX; SCANTLEBURY, 2016) in a process in which asymmetries between participants are no longer obstacles, but opportunities for alterity and valuing diversity. This process takes place in cycles and is guided by dialogue. As a result, the cogeneration of educational proposals – the cogenerative dialogues (cogen) –, occurs (CORRÊA; SILVA; MARTINS, 2018).

Co-teaching is structured in a set of activities that unite action and reflection, constituting a praxis (TOBIN *et al.*, 2001; TOBIN; ROTH, 2005; ROTH *et al.*, 2004, 2005) in which cogen is a central element. We represent co-teaching as a cycle, which begins with co-planning, passes through co-teaching and co-evaluation, evolving to cogen, which has the role of looking at the entire process, reflecting and producing knowledge about teaching and learning of students at the school and on the process of professional training of those involved with co-teaching. After cogen, the process starts over with co-planning.



*Fig. 1 – Stages of co- teaching development. Source: the authors.*

This model is based on both values and forms of action that structure relationships between subjects. Attention, trust, respect, harmony and circulation of leadership are the elements that structure co-teaching (Fig. 2). Knowledge of these elements by the subjects who work together is fundamental for success. Attention, trust and respect are the foundations for the necessary harmony between subjects, allowing the circulation of leadership to occur. The constitution of horizontal relationships is a dynamic process, a continuous movement. It is an unstable equilibrium situation, considering that the relationships between subjects always take place in the context of arenas of hegemonic struggles (RESENDE; RAMALHO, 2014). When we speak, therefore, of leadership circulation, we are admitting that the position of whoever is in charge of the activity is not permanent, nor is it determined by their primary agency (supervisor, intern, student, guiding professor). As an example, we can think of the relationship between interns and supervising teachers as they co-teach. Based on co- teaching, it is expected that supervisor and intern will alternate in central positions of content development and class management. Every time someone has the floor, he puts himself in the lead, always provisional and open to alternation.

Thus, training based on co- teaching is opposed to models based on technical rationality and values reflection on the part of the agents involved, in the manner highlighted by Zeichner (2008). For this author, “the process of understanding and improving one's own teaching must begin by reflecting on one's own experience and that the type of knowledge arising solely from the experience of other people is insufficient” (p. 539). It also highlights how fundamental it is to explore contextual elements of the process, since the scenario in which the activities are developed not only impacts the way the participants act, but demands the recognition of specificities and nuances that cannot be reduced to standardized behaviors or applications of formulas. In this way, the potential of establishing a network of action and collective work in the elaboration and conduction of intervention proposals in the classroom is perceived.

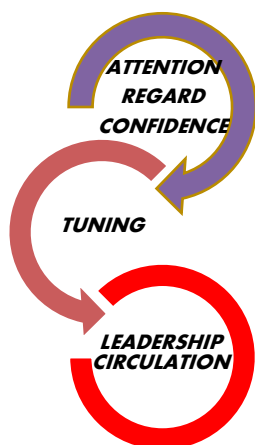


Fig. 2 – Values and actions that underlie co-teaching. Source: the authors.

### III. Theoretical Reference

The analyzes were based on elements of Critical Discourse Analysis (CDA) and social semiotics (KRESS *et al.*, 2001). Both CDA and social semiotics deal with the relationship between language and society, considering language as a constituent element of social practices, that is, being determinant and determined by these same practices. As constitutive elements of social practices, discourses relate to “all semiotic elements that are part of social life, in its multimodality of meaning: written text, gestures, facial expressions, images, caption, etc. In this sense, discourse is semiosis” (BARROS, 2015, p. 69).

From CDA, we bring discursive categories linked to the meanings of language proposed by Fairclough (2003). For the author, discourse appears in different ways: as ways of acting (actional meaning), of representing (representational meaning) and as ways of being (identificational meaning). For each meaning there are analytical categories, which reveal textual aspects linked to social dimensions. For this work we focused on actional meaning, mobilizing speech functions such as statements, questions, demands and offers. They represent the ways in which subjects relate to each other, in the form of exchanges of knowledge (statements and questions) or of activity (demands and offers).

These dimensions will be used in the analysis of the relationship between residents and the preceptor teacher, which occurs mainly in the form of demands addressed by the preceptor teacher to the residents. In the constitution of these demands, we will note aspects associated with the representation of social actors, by appointment, for example, in which social actors are identified by their names. This form of representation generally denotes the appreciation of the named actor (RESENDE; RAMALHO, 2014).

We looked at the interaction of teachers, while they co-teach, among themselves, with their students and with the mediation instrument present in the activity (an experimental model that allowed students to manipulate it). We looked at the different texts produced as a

means of production of meanings, which can be constituted by different semiotic modes (RESENDE; RAMALHO, 2014).

To analyze gestures, positions and looks, we used Kress *et al.* (2001) that explores interactions between the subjects from the point of view of multimodality. The authors argue that only written and spoken text do not operate alone in the construction of meanings. “Meaning resides (...) in the interaction between what is said, what is shown, the posture adopted, the movements made, and the position of the speaker and the audience in relation to each other in the interaction” (KRESS *et al.*, 2001, p. 14).

## **IV. Methodology**

This research is a case study and was based on data generated in the field, in the monitoring of internship activities linked to the PRP. It was a qualitative research motivated by the quest to understand the educational potential of co-teaching for the different subjects involved in the experience: basic education students, interns, experienced teachers (from the university and the school).

### **IV.1 The research context**

In Co-teaching teacher training based on the work carried out by teachers in their classrooms. It incorporates spaces for collaboration that allow the involvement of the university's social actors, in this case, the coordinating professor of the PRP, the researcher and the residents. These spaces are co-planning meetings, co-teaching situations, co-evaluation and cogens. The participation of these different actors is not mandatory at all times, but it is undoubtedly desirable. In the case presented here, we had the participation of all the actors in co-planning meetings and only the presence of the residents and the supervising teacher in the co-teaching activities.

The co-teaching situations are the result of the didactic sequence designed in the co-planning meetings and followed a theoretical orientation guided by Freire's transformative education (1987), which is opposed to banking education, that is, simple reproduction and deposit of contents, considering the students as objects in a relationship of domination by the educator over the student. To understand education as a practice of freedom, education needs to be problematized. Freire tells us about educators-students, “subjects who meet for the pronunciation of the world, for its transformation” (p. 227). Thinking about education from Freire's perspective means understanding that the teaching-learning process takes place through collaboration, union, organization and cultural synthesis. These assumptions are also present in co-teaching, as a way of involving social actors from the university and the basic education school in the training processes that take place in these two spaces. Co-teaching frames teacher training from the point of view of the school.

The topic chosen for the development of the didactic sequence was the electric energy generation and electrical plants. Our problematization of electricity generation went beyond the direct relationship between teachers and students, as it began in the dialogue between university and school through co-teaching. With it, other social actors were included in the social relations established within the school. The coordinating professor, researcher and residents (university subjects) worked together with the preceptor teacher and her students (school subjects) to problematize aspects of scientific knowledge and of society.

In the approximation with the Freirean reference, the didactic proposals are based on participatory classes, as opposed to content reproduction systems. This implies exchange between students and teachers from problem situations that mobilize the subjects for their understanding. For Freire (1996), there is no educational practice dissociated from the formation of the individual. In this way, the need for a connection between classroom physics and scientific issues present in society under different aspects is highlighted, especially those that value the role of knowledge in social transformation (AULER; DELIZOICOV, 2006).

In this study, such dimensions of the learning process are contextualized in relation to the objectives of the main curriculum orientation document of the State of Rio de Janeiro, called Minimum Curriculum (BRASIL, 2012), which seeks to value the incorporation of historical processes and social issues and environmental issues to education (FERNANDES, 2015).

In table 1, we can observe the synthesis of the activities proposed in the didactic sequence developed.

Table 1 – Summary of activities carried out during the “Generation of Energy and Sustainability” Project.

Activity	Description
<b>1. Initial problematization on the topic of electricity generation</b>	Guiding questions were presented to the students. 1) Where does electricity come from? 2) What is sustainability? 3) How to generate energy in a sustainable way? 4) What does the group understand by energy source and energy matrix?
<b>2. Investigate students' conceptions on the topic of energy production and sustainability;</b>	Students distributed in small groups. Each group presented their ideas regarding the questions that were suggested. This approach helped to survey the students' initial conceptions.
<b>3. Resume the discussion on energy matrices and differentiate energy sources from energy</b>	Following group presentation, the topic of electricity production was resumed. The idea is that the theme would be presented in reverse, for example, starting from the consumption of a house, passing through the transmission networks and arriving at the energy matrix

<b>matrices;</b>	(hydroelectric, thermoelectric, etc.) of the path taken by electrical energy.
<b>4. Construction of an experimental apparatus</b>	Materials were distributed together with the exposition of a “problem” to be solved: how to light a LED using, first, a fan associated with an apparatus for producing steam with recyclable material?
<b>5. Return to the subject of energy matrices and plants</b>	Aspects related to hydroelectric, wind, geothermal, photovoltaic, heliothermic, nuclear and tidal power plants were addressed. In addition to presenting the content, the idea was to recognize the extent to which students distinguished the functioning of each one, differentiating the matrix from the energy source, in addition to their advantages and disadvantages. At the end, then, the debate of the first class was resumed, so that a new reflection could be made about the chosen solutions.

#### IV.2 The data generation process and the selection of analysis episodes

Data were constructed from video recordings of two co-teaching events. In the first one (event N) we had the joint action of the preceptor teacher and one of the residents. In the second (event O), we observed the relationship between the preceptor teacher and two residents. The final report of the trainees, made together with the supervising teacher, served as a data source for the description of the didactic sequence produced.

Our empirical material is, therefore, the transcribed texts and the images generated by the video recording of these two co-teaching experiences. For the description of the analyzed actions, we used fictitious names for the teacher, who will be named as Carla, and for the residents, who will be named as Carmen and Mauro.

In co-teaching, the processes linked to teaching work, that is, planning, teaching, evaluation and reflection, are always collective and count on the presence of subjects from university and school. Therefore, in our footage, we have information on the forms of interaction between these subjects, in their multiple modalities: oral text, gestures, positions, expressions. With video recording it is possible to capture “facial expressions, gestures and body actions, which characterize interactions and which also play, together with verbal language, an important role in the construction of meanings” (MARTINS, 2011, p. 305).

The analysis of the video recordings was made from the organization of the filmed events in episodic clippings (episode map). The episodes identify the participants, the themes of their conversations and the duration, facilitating the identification of elements of interest for the research, as well as the transcription of the speeches. Along with the transcripts, we have the support of images as a semiotic mode of analysis to describe the ways of acting of the different subjects of the activity. Non-verbal semiotic elements (expressions, gestures, smiles, looks) are identified in the images (circled) and correlated through arrows, which seek



to represent the convergence or divergence in the ways in which the different subjects participating in the action relate to each other.

Table 2 shows the episodes selected for the two co-teaching experiences that were analyzed in this work. Only the episodes that fed our analysis are kept, as they present semiotic elements that show relationships between the participants mediated by the experimental activity.

Table 2 – Map of episodes with episodic clippings of events N and O.

EVENT	ACTIVITY	EPISODES
N	co-teaching	<p><b><u>Episode I:</u></b> Explanation of the electromagnetic process of generating electrical energy.</p> <p><b><u>Episode II:</u></b> Exposure of the internal mechanism of a generator.</p>
O	co-teaching	<p><b><u>Episode IV:</u></b> Carmen asks the students for attention and starts the class, presenting the objectives of the activity.</p> <p><b><u>Episode VI:</u></b> Carmen resumes speaking.</p> <p><b><u>Episode X:</u></b> Carmen resumes speaking and some students, along with the supervising teacher, ask for silence. She announces the break, but the students ask to go straight ahead.</p> <p><b><u>Episode XII:</u></b> Mauro leaves to solve something, while Carmen resumes talking with the help of Carla, who asks the class for attention. She gives some instructions to the students so they can start setting up their experiments.</p> <p><b><u>Episode XIV:</u></b> Mauro seeks to begin the explanation of the experiment.</p> <p><b><u>Episode XVIII:</u></b> Mauro resumes the explanation of the experiment.</p> <p><b><u>Episode XIX:</u></b> Some students join the interns and the preceptor teacher to adjust the position of a system of paddles in front of the stream of steam coming out of the can in order to move the paddles.</p> <p><b><u>Episode XX:</u></b> Carmen warns the gang, who had dispersed, that they managed to provoke the movement of the blades with the flow of steam. Everyone observes the phenomenon.</p> <p><b><u>Episode XXI:</u></b> Carla places an electric generator powered by a system of blades and connected to an LED for students to interact.</p>

We will refer to the episodes highlighted in this table when carrying out our analyses.

The situations that we analyze here refer to the fourth moment of the didactic sequence (Chart 1), experienced in two different classes. In the first one (event N), we have the experience of co-teaching between Mauro (resident) and Carla (preceptor teacher). In the second experience (event O), co-teaching takes place with the presence of Carmen (resident), along with Mauro and Carla.

At this stage of the didactic sequence, we seek to understand the process of energy generation from the manipulation of a model that simulates the process of energy generation in thermoelectric plants. The planned activity was such that students were divided into groups, which would receive the necessary materials for the construction of an experimental setup, whose objective was to be able to turn on a led.

We chose two episodes of event N, which show changes in the resident's teaching strategy due to the relationship established between him and the preceptor teacher. We discuss the effects of this relationship on student behavior change.

In event O, we highlighted the centrality of the experiment and the strategy of stimulating students to interact with the apparatus. Again, we will see the role played by the preceptor teacher in organizing this mobilization of students.

The use of experimental activities as a strategy for teaching Physics has been pointed out by teachers and students as one of the most fruitful ways to minimize the difficulties of learning and teaching Physics in a meaningful and consistent way (ARAÚJO, ABIB, 2003).

The classic way of proposing and carrying out an experiment is one in which there is no possibility of discussion at the time of manipulation of the apparatus. The student learns to use materials and instruments, to operate a method, to manipulate a law by varying parameters and to observe the effects caused by these variations in a phenomenon, with the objective of confirming theoretical predictions, or determining previously known data.

In proposing this activity, we aimed at developing an approach that was dissociated from what we find in most support manuals or textbooks available to help teachers work and that are based on "cookbook" guidelines, in addition to strongly associated with a traditional teaching approach. We can observe that such guidelines are restricted to closed demonstrations, verification of hypotheses and confirmation of the previously defined theory.

In order to analyze the interaction and engagement of the subjects, we propose an experiment based on an open question. According to Borges (2002) this type of experimental activity has a unique characteristic that is to combine processes, concepts and procedures in the solution of a problem. The author highlights the activity demands attention and assistance from the teacher, that this form of organization of the practical activity captures the attention of the students and improves their involvement with the activity. During the stages of problem solving, there are feedback cycles for the previous stages, coming from the perception that changes in planning, in the formulation of the problem or in the experimental techniques used and throughout the process were needed.

## V. The relationship between the preceptor teacher and the resident in event N

The first episode of the N event shows Mauro (resident) explaining how an electromagnetic generator works, while Carla (preceptor) follows the entire process by filming the event with her cell phone. He seeks to explain Faraday's Law to show how electrical energy is generated, as expressed in the excerpt below taken from the transcript of episode I.

### N - I

6 - Mauro [Class]: *So , because, really, when we talk about, yeah, processes like that, yeah, many people don't comment on what's behind the generation of electrical energy. Yes, inside the generator something is happening that we call Faraday's Law. Faraday, he is a physicist who discovered that when I pass a magnet inside a conducting wire, I can generate electrical energy. So, yes, this material that is inside the generator, it is nothing more than a magnet, which is rotating around several conducting wires wound several times, as if it were a loop. And, when I make this movement of turning this magnet that is around these wires, these wires they cause an electric current, yeah, this magnet causes the electric current in these wires.*

In Fig. 3 a, we see Mauro, and some of his students. A small group had their attention turned to the model of a boiler, whose steam output should move a system of blades. Mauro sought to show how an electromagnetic generator works and was constructing his explanation mediated only by gestures that sought to describe the way the generator's parts behave, seeking to articulate his description with Faraday's Law. With his gestures, Mauro manipulated an abstract model of a generator. His actions were disconnected from the experimental model that his students manipulated.

It is possible to notice in the image, by the representation of the arrows, that the students had their eyes turned to the experimental model of the boiler (blue circle) and to the steam output that would produce the movement of a small system of blades that one of them holds. Another, right behind Mauro and next to the window, was inattentive and did not interact with either Mauro or the model.

At that moment in the class, there was a disconnect between the conceptual construction that Mauro was trying to do and the experiment. Students had their attention dispersed between experiment, teacher explanation and other interests.

At one point, the preceptor teacher interrupted the explanation that Mauro was constructing to assign her a demand. So, she uses naming to indicate what needs to be done:

7 - Carla [Mauro]: *Here, Mauro. I think this one is not exposed, the...*

This demand, not finalized by Carla, is understood and answered immediately by Mauro, who seeks a prototype of an electromagnetic generator in which he can expose the mechanism and show it to the students.

8 - Mauro [Class]: *I'll get it there to show you...*

Next, Carla addresses the class, seeking to arouse their curiosity about what Mauro is going to present.

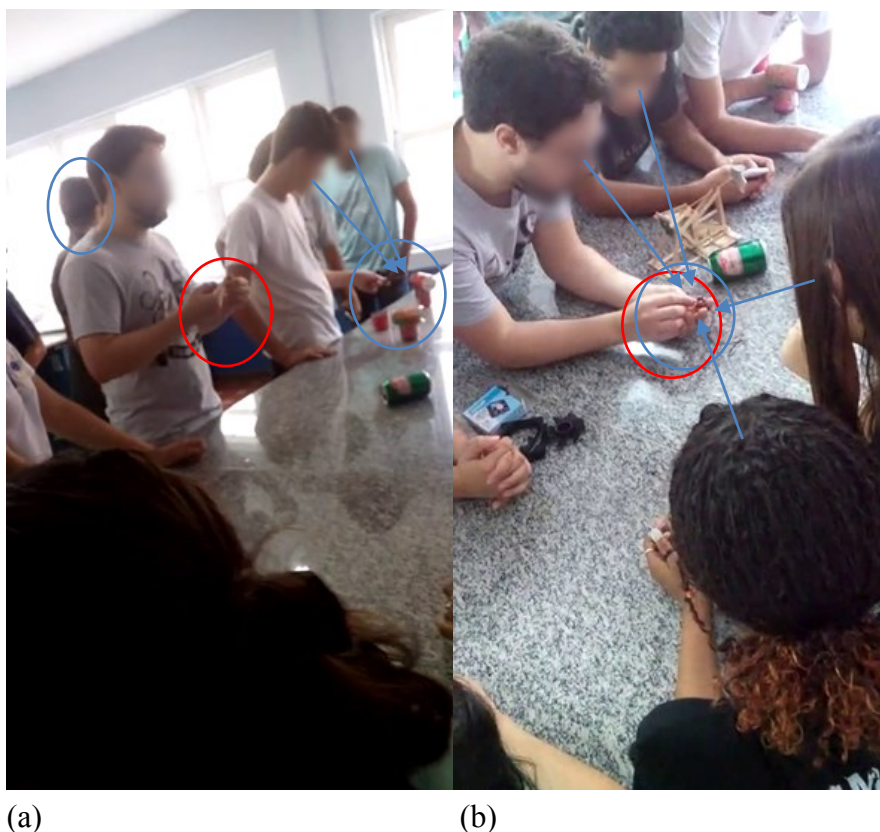


Fig. 3 – (a) Mauro tried to explain the operation of a generator from his gestures, while the students had their attention turned to the functioning of the model. (b) Mauro then started manipulating a generator model and this change brought greater student engagement with his explanation.

9 - Carla [Class]: *Have you guys seen it inside the little motor? That little motor there, guys, I won. It was a student who built it for me, a student.*

She tries to get closer to the students, creating an identification between them and the experimental apparatus when she reveals that she won the little motor and who built the structure that Mauro is using was a student. There is an affective appreciation process “*That little motor there, guys, I won. It was a student who built for me, a student*”.

Carla's way of acting, through a demand directed directly at Mauro, caused changes in the way he related to the students and the content. He went from an explanation that was supported by his speech and gestures, to another, in which his speech is supported by the experimental model, possible to be manipulated directly. His gestures no longer build an

abstract generator, he uses a model to mediate his communication with the students and with the theory he intends to explain.

We can notice from Fig. 3 b, that this change in Mauro's way of acting also changes the way in which the students got involved in the activity. It is possible to notice, by the position of the students, who are closer to each other and to the teacher and by the direction of their gaze (represented by the arrows), that there was convergence towards the model that is being manipulated by Mauro. Mauro's gestures were no longer disconnected from the experimental model and also converged.

Carla acted in co-teaching as someone who is attentive to the behavior of her students and the resident. His way of acting, through a demand, brought significant changes in the ways in which the students and the resident were relating. It revealed the potential of the experiment as a mediator of these relationships and resulted in greater student engagement in the conceptual elaboration conducted by Mauro.

## **VI. The interaction of subjects with the experiment and its effects on engagement with the activity**

The second analyzed event (event O) deals with the same stage of the didactic sequence analyzed in event N. At this stage of planning, it was for the students to find the solution to a problem (turn on a led) from the materials they had. Despite these intentions, the group of residents and the preceptor teacher, who co-teacher, started to use the experimental model as a mediator for their explanations about the process of generating electricity.

The beginning of the class is done by Carmen (resident). This one is very troubled. Most students are scattered and there is a lot of fun. The preceptor teacher seeks to support the resident by acting with silence requests, a class management activity, whose conceptual development had been left to the residents. We will see in the fragments below, portraits of various moments of the class, which show the efforts to organize the class.

### **0 - IV**

1 - Carmen [Class]: *Guys, let's go! Do you know what we're going to do?*

2 - Class [Carmen]: *No!*

3 - Carmen [Class]: *We are going to produce a plant here.*

4 - Students [Class]: *Shush!*

5 - Student [Class]: *Hey!!!!*

## O-VI

Students are talking a lot to each other.

7 - Carmen [Class]: *Attention guys, look! You're going to do [inaudible].*

8 - Students [Class]: *Shush!!!*

9 - Student [Class]: *Guys, she's talking.*

## O-X

12 - Carmen [Class]: *Guys [inaudible] ...*

13 - Carla [Class]: *Shush!!!*

## O-XII

19 - Carmen [Class]: *[Inaudible] ... while it's getting hot here [Inaudible].*

20 - Carla [Class]: *Shush!!! Hey guys!!!*

21 - Student [Class]: *Let her talk!*

The students started to behave in a more organized way from the moment Mauro starts the conceptual development stage of the class, asking the class questions about the energy transformation processes that occur in the boiler model they are observing. This will happen in Episode XIV, 21 minutes after the start of class. Mauro uses the experiment as a mediator for the conceptual construction he seeks to develop.

At one point in the explanation, Carmen receives from the preceptor teacher a rod that contains a system of blades that must be placed in front of the steam so that she can demonstrate the production of movement as a result of the energy transformation. From there, everyone's attention is turned to the paddle system, which needs to move in front of the steam flow. Several hypotheses are raised by the students in order to correctly position the blade system in relation to the steam flow. At that time, only the residents were handling the experiment trying to get the position right. The difficulty in being able to produce the movement seems to discourage students, who disperse again. Fig. 4 a and b, show the break in students' expectations, evidenced by the emptying of space.



(a)

(b)

*Fig. 4 – Students are attentive to the attempt to make the model work. (b) Faced with difficulties, students disperse.*

In view of this, the preceptor teacher then assumes the role of trying to position the system correctly and the students just observe. Despite not handling the experiment directly, some students are attentive and seek to contribute with their ideas so that the problem is solved. When the system finally kicks in, students who had dispersed are called back. We can see in Fig. 5, Carmen waving to call the students to see the result, denoting the perception she had of the expectations that the students had in relation to the success of the model.



*Fig. 5 – After the shovel system starts moving, Carmen calls the students who had dispersed to come back.*

Fig. 6 shows the convergence of views of all participants towards the experiment, which is the main mediator of the relationships between the subjects, after the preceptor teacher manages to correctly position the paddle system in relation to the steam flow.

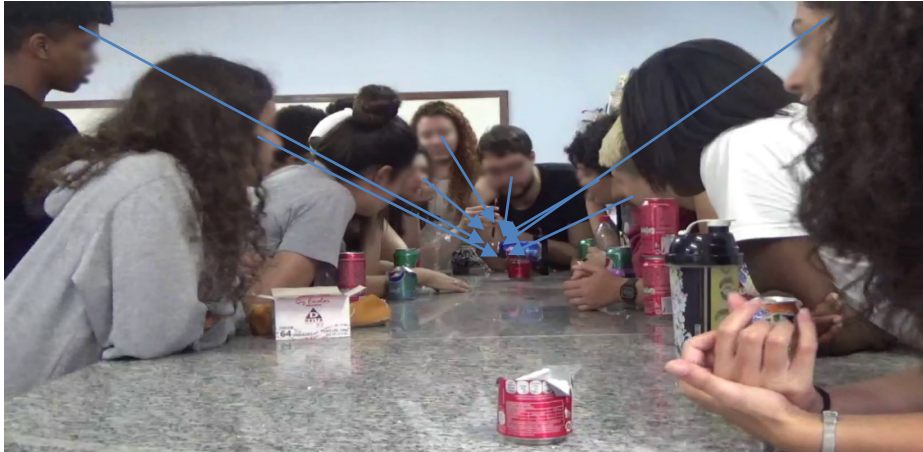


Fig. 6 – The preceptor teacher holds the paddle system and everyone, including the residents, observes the movement of the system.

Once the problem of the movement of the blades is solved, the group focuses on using this movement to light an LED, which was the problem initially thrown. And who took this path was a student, from a question:

#### O - XX

67 – Student [Mauro]: *But, hey Mauro, if I blow this little thing will it generate energy in the lamp?*

68 – Mauro [Student]: *If you blow too hard, yes.*

The student's question made the preceptor teacher take the lead in co-teaching and introduce another element, another experimental model, a prototype of a wind generator, in which the blade system is connected to an electromagnetic generator and this connect an led. It introduces this new mediating instrument and along with it changes the way students engage in the activity. Now, they have more protagonism and interact directly with the experiment.

#### O - XXI

69 - Carla [Student]: *W... take this thing for me, in my bag.*

70 - Student [Carla]: *This one?*

71 - Carla [Student]: *No. In my bag. Toothpick. With toothpick.*

72 - Carla [Student]: *Go... you wanted to blow, blow.*

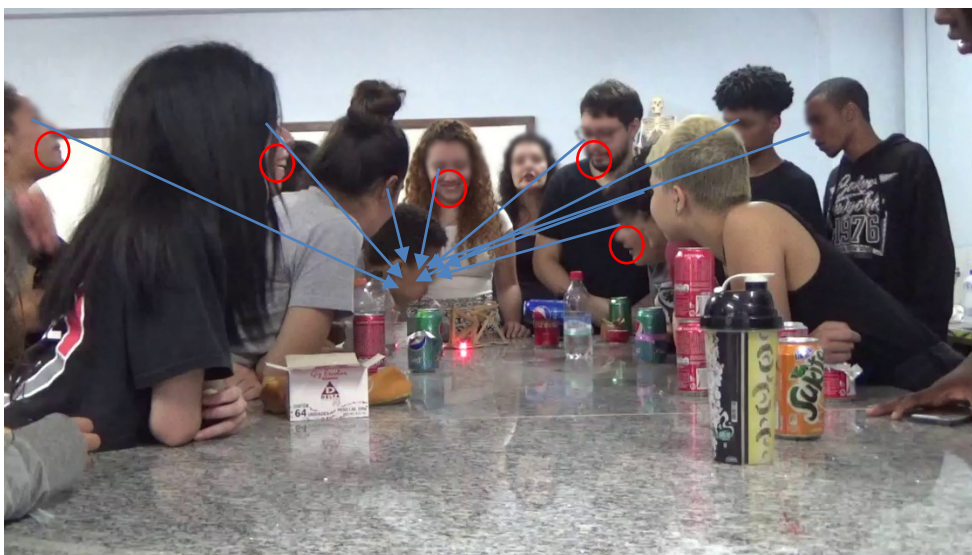
When Carla turns to the student and asks her “Go... you wanted to blow, blow”, her way of communicating is not understood as an order, in the imperative, but as an invitation to



action. The student blows and manages to turn on the led. This encourages the entire group, which celebrates the feat together with the student and makes room for other students to interact directly with the experiment.

Fig. 7 shows the instant when another student blows and manages to turn on the LED. The center of attention becomes the student blowing and the end result of turning on the LED. It is possible to see in the figure how the eyes are turned towards the person who blows and the different expressions on the faces of the students and teachers.

The change in strategy led by the preceptor teacher when she takes the lead in co-teaching changes the way students and residents behave in the face of the activity. Exploring the experiment as an instrument to expand the students' protagonism, Carla promotes their engagement. We can characterize this engagement through multimodal elements of meaning construction (KRESS *et al.*, 2001), based on the analysis of Fig. 7.



*Fig. 7 – The engagement of the participants with the activity.*

- (i) Convergence of gazes;
- (ii) Physical approach;
- (iii) Bodies projected towards the activity;
- (iv) Different emotional reactions: smiles, attentive expressions, expressions of surprise, satisfaction.

The history of this co-teaching experience showed the difficulties encountered by residents in getting students' attention, in manipulating the experimental model, and the ways in which these obstacles were overcome through collaboration between the preceptor teacher and the residents.

By the time they participated in this co-teaching activity together, the residents and the teacher had built bonds with each other, which strengthened trust and respect between them. This previous process, of co-planning, was not the object of analysis in this work, but

its reflexes were felt in the activity. Co-teaching is not a momentary experience, but a process built over time. It is only possible to co-teach when planning together.

When the preceptor teacher offered Carmen the shovel system, so that the model could be manipulated, she showed how attentive she was to the actions of her students and residents. Her perception that the success of the model would produce changes in the course of the class, made her change her behavior in co-teaching, moving from a secondary position, just managing the class, to a more central one, alongside the residents and participating of conceptual development. This leadership circulation effect is expected in co-teaching and produced important effects in the teaching-learning process that was being conducted. These are effects not only on the students' ways of acting, but also on the residents, whose relationships with the students and the preceptor constituted their identities as teachers throughout the co-teaching process.

## **VII. Final considerations**

This work showed the potential of collaboration between the university and the school of basic education in the sense of proposing collaborative training models, which involve the participation of different actors in the educational process. We argue that, as it is developed in collaboration and stimulates constant exchange and interaction, the co-teaching model implies the deconstruction of fixed social roles (resident, preceptor, trainer) and promotes changes in the participants' ways of acting and being.

The results show that the heterogeneity of the groups, from the point of view of their experience and professional performance, resulted in expanded opportunities for training for all participants. The research carried out focused on the specificities of high school classes, especially with regard to commitments to student learning, as privileged spaces for teacher training. On the other hand, it demonstrated the positive role of introducing curriculum proposals that renew practices and expand didactic possibilities.

The work significantly focused on the development of experiences detached from the reality lived by the students, which resulted in a greater participation of the students in the activities. The students' mobilization around the manipulation of experimental models from a problem, in an open activity, showed the potential of this type of activity as a mediator of the relationships between teachers, students and the content.

Finally, we consider that the established dialogues brought the university closer to the school and the school to the university. Thus, the continuity of this proposal for the teaching of physics in high school is encouraged, giving rise to new connections and improvements. We can see, with the articulation between the actors involved, preceptor teacher, residents and university professors, a great potential for the development of didactic proposals that promote more effectively aspects related to theory and practice in the context of teacher training and practice.

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