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ARTICLE

PERFORMANCE, EDUCATION AND PHYSICS EDUCATION: UNANTICIPATED APPROXIMATIONS

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ABSTRACT: The article seeks to explore the meanings that a critical performative pedagogy can acquire in the context of physics teaching. We start from a reflection about the movements of thought that the notion of performance provokes, especially in the contexts of education and science, in order to delimitate what critical performative methodologies can be. A series of narratives of educational experiences in the context of an undergraduate degree course in physics and an extension-program project in state public schools lead to reflections focusing on three fundamental aspects of these works: the poetic experience of the ephemeral, the presence of a body that reflects and creates, and the possibilities of stressing and playing with the norms that structure school relations.
Keywords: Education as performance; Art-science-education; Arts based research; The body in physics education; Freeing education.

PERFORMANCE, EDUCAÇÃO E ENSINO DE FÍSICA: APROXIMAÇÕES IMPREVISTAS

RESUMO: O trabalho busca explorar os sentidos que uma pedagogia performativa crítica pode adquirir no contexto do ensino de física. Para tanto, parte de uma reflexão a respeito dos movimentos de pensamento que a noção de performance provoca, especialmente nos contextos da educação e da ciência, para então estabelecer alguma delimitação do que sejam metodologias performativas críticas. A seguir, uma série de narrativas de experiências educacionais vividas, no contexto de um curso de licenciatura em física e de um projeto de extensão universitária atuante em escolas públicas estaduais, conduzem à reflexão, enfocando três aspectos fundamentais desses trabalhos: a experiência poética do efêmero, a presença de um corpo que reflete e cria e as possibilidades de tensionar e colocar em jogo as normas que estruturam as relações escolares.
Palavras chave: Educação como performance; Arte-ciência-educação; Investigação baseada nas artes; Corpo no ensino de física; Educação libertadora**.**

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INTRODUCTION

This study aims to explore the interactions between the concept of performance and the fields of education and the natural sciences and, in particular, to investigate the potentialities of the use of critical performative methodologies in the context of physics education. Defining the possible meanings of such interactions and what the characteristics of these methodologies are is a daunting task since the concept of performance, as discussed throughout this study, seems, historically, not to have been established as a precise or exact concept within a specific theoretical context. Rather, it has developed as a hybrid concept running through an extremely heterogeneous set of fields in an exceedingly powerful way, refusing to fit itself into a single definition. Thus, the following procedure will be adopted for exploring the proposed interactions. First, based on readings about performative approaches found in various disciplinary contexts, several common meanings involved therein will be identified. This may help explain the type of thought movement conducted by such approaches with a focus on the fields of education and nature. Second, after assuming certain defining principles of what critical performative methodologies mean in the educational context, the narratives of several pedagogical events will be adopted as the common thread for a more experiential reflection on the possible meanings, possibilities, and potentialities of these methodologies.

A commentary on the motivation of this study may be the best way to introduce it to the reader. Since 2009, I have been systematically investigating the possibilities of what I now call critical performative methodologies in the context of physics teaching and teacher training. First, during the development of my doctoral thesis (Crochik, 2013), I investigated the potentialities of the relations between art and science, especially in the use of theatrical games in physics teacher training. Since 2006, I have been working on a teacher training course. I conducted a large portion of this study while teaching a course called *Workshop on Teaching Projects*, in which we investigated scientific and pedagogical themes through procedures largely inspired by the systematic examination of theatrical improvisation games developed by Viola Spolin (1998). This course was linked to student internship activities so that the research material was associated both with my experience with the trainees and with the reports of their experiences in the high schools where they were interns. In 2015, I started coordinating a university extension at the same institution – the *Art-Science Project at*

School – focusing on the development of interventions in state high schools that would approach the relations between art, science, and education in several ways. These interventions are created together by the scholarship holders of the project, most of whom are physics teaching trainees and teachers who are part of the team, based on (i) studies and experiences surrounding specific artistic languages, (ii) an investigation into the relations between these artistic languages and scientific activity, and (iii) close contact with the partner schools where interventions are carried out. The interventions that occur in these schools produce the data that are to be thoroughly investigated in the project. The pedagogical events narrated in the second part of this study stem from the experiences in these two research contexts.

The relations with the theater that were explored in these two studies were less connected with theatrical performance as an artistic *product* and more with the use of *processes* associated with theatrical practice to conduct investigations into both scientific and educational issues. Therefore, the idea arose of collaborative theatrical rehearsals and theatrical improvisation work. These are movements in which subjects are placed in bodily relations, but not in order to repeat certain behaviors that had been previously planned; rather, they were meant for the collective production of an event still unknown by all at the present time. They served as a paradigm for how to investigate, think, and learn. I emphasized the process through which we can learn and investigate from a relationship involving the subjectivity of each participant in an explicit and bodily way. Furthermore, I found a perspective quite similar to the one I had already been working with in the Elyse Lamm Pineau's (2002) definition of critical performative methodologies. This author proposes the following agenda for the educational field (to a certain extent, this has motivated me to deepen my reflections on the context of physics teaching):

> Think about what it means to teach performatively across disciplines and at all levels of curriculum design and implementation. (…) What would a course look like—and more importantly, feel like—if the syllabus were designed according to the model of collaborative group rehearsal? Can performance methodology be integrated across the curriculum in the ways that writing has come to be implemented? An important test of critical performative pedagogy will be to apply it as fruitfully to courses in the hard sciences as to those in the performing arts (PINEAU, 2002, p. 53).

This methodology has provided me with a number of valuable experiences for my pedagogical research. Further, I observed an indication of how relevant this reflection is while witnessing the Occupy the Schools movement in 2015 in São Paulo. As I intend

to argue in a future study, the Occupy the Schools movement and the unexpected appreciation of the physical space of the schools developed by their students transformed them into places where learning and political action could occur based on the encounters between the subjects found there. Moreover, they revealed how important it is for these students to create ways of learning that value the collective production of thought without dichotomizing body and mind, theory and action, representation and reality, or discipline and pleasure. This can be confirmed in the practices promoted by the students during the Occupy the Schools movement, as well as verbal statements from some of these students such as the following:

> In school education, we are extremely accustomed to looking and being seated one student behind the other. We do not have this eye contact. There are people who have studied here for four or five years, and I tell them, "Wow, I have never seen you, and now that I can look into your eyes, I can understand you, I can see you..." We learned to see here inside (quoted in CAMPOS, MEDEIROS, & RIBEIRO, 2016, p. 134).

As previously stated, I will begin by developing a concept, although not one based on explicit definitions, from some of the uses that the concepts of performance and performativity present in several disciplinary fields to discuss ways of establishing relationships between performance and education and between education and the natural sciences. Following that process, the meanings, possibilities, and potentialities of the use of critical performative methodologies will be discussed, based on the narratives of several events that happened during the *Workshop on Teaching Projects* course and the *Art-Science at School* university extension project. We will reflect upon three remarkable characteristics of these methodologies: The poetic experience of the ephemeral, the presence of a body that reflects and creates, and the possibilities of stressing and questioning the norms that structure school relations.

THE CONCEPT OF PERFORMANCE AND ITS RELATIONS WITH EDUCATION

> Learning to read and write is an opportunity for women and men to notice what it means to say the word: a human behavior involving action and reflection. In a true sense, to say the word is to have the right to express oneself and the world, to create and recreate, to decide, to choose (FREIRE, 2001, p. 59).

The concept of performance presents an increasingly broad and relevant spectrum of uses and meanings. This is seen in several fields as varied as the theater and visual arts, anthropology, philosophy

of language, and gender studies. Considering the many meanings in which performance is referenced, a common element may be the questioning of the duality between representation and event.

John Austin's How to Do Things with Words (1962) played a relevant inaugural role by addressing "performative utterance," alluding to its ability "to do things," to produce events, rather than merely representing them. When a judge declares two people "husband and wife" or the president of one country declares war on another, these individuals are not symbolically representing a world event, but rather producing this very event through their words. Similarly, as Judith Butler stated (1993), when a doctor declares that a newborn (or a fetus) "is a boy," he is not only representing reality, but producing an event and reproducing an identity. A biopower is established by reiterating discourses and practices; not only does it repress, it also conduces and promotes ways of being and relating. As mentioned by Butler (2017, p. 35), "the point is not only that language acts, but that it acts powerfully."

When discussing the performative character of language, we discover a space of events and action in a universe that is, at first, symbolic and representational. In the opposite direction, we may think about the performative character of certain events by acknowledging a space for representation and, consequently, some kind of theatricality. Richard Schechner (2002) is an important reference in the field of performance studies: he tries to understand events as varied as theatrical presentations, rituals, religious manifestations, political demonstrations, and games according to the concepts of performance and performativity. This questioning of the duality between representation and event is expressed beautifully in the following quotation by Augusto Boal, which serves as the foreword to Schechner's book:

> Usually people say that a truly artistic show will always be unique, impossible to be repeated: never will the same actors, in the same play, produce the same show. Theatre is Life. People also say that, in life, we never really do anything for the first time, always repeating past experiences, habits, rituals, conventions. Life is Theatre (BOAL, quoted in SCHECHNER, 2002, p. vi).

The concept of the "restored behavior" discussed by Schechner poses the question of how it is that spontaneous daily gestures are part of a network of quotes and repetitions, such that we never perform a real action for the first time, but "always for the second to nth time" (SCHECHNER, 2002, p. 36). Regardless of the social cause that may have been responsible for the emergence of a certain pattern of behavior and relations, this network of quotes and repetitions takes on a certain autonomy, even if what caused it is no longer present.

Nonetheless, performativity involves not only the processes of repetition and reproduction, but also the way in which unforeseen forms of acting can emerge and thus represent, simply by their appearance, a questioning, a threat to a certain stratified structure of relationships. The concept of gender performativity by Judith Butler serves again as an example. "Gender is received, but surely not simply inscribed on our bodies as if we were merely a passive slate obligated to bear a mark" (BUTLER, 2017, p. 37). The process of the reproduction of gender standards involves embodied practices that never manage to perfectly identify themselves with a specific "ideal" model of identity. In the successive performative representations of these rules, there is room both for their repetition and reproduction and for the possibility of creating new, unforeseen configurations. When put into action, the gender norms are simultaneously reproduced and submitted to transformative possibilities:

> So, first and foremost, to say that gender is performative is to say that it is a certain kind of enactment; (...) the reproduction of gender is thus always a negotiation with power and finally, there is no gender without this reproduction of norms that in the course of its repeated enactments risks undoing or redoing the norms in unexpected ways, opening up the possibility of remaking gendered reality along new lines (BUTLER, 2017, p. 39).

On the one hand, the concept of performance allows us to focus on the repetitions and reiterations that characterize our apparently unique and original life; on the other hand, it draws our attention to precisely the unrepeatable, transient, and, therefore, irreproducible character of events. Repetition implies a transformation, and the transformation arises from a long process of repetition, so these two concepts do not contradict but, instead, complement one another. Consequently, analyzing the performative character of events and representations does not involve concerns about the alleged static and permanent results that they would produce as much as it involves regarding the experience of the process itself in consideration of its impermanence. "The disappearance of the object is fundamental to performance," writes Peggy Phelan (1993, p. 147). "Performance in a strict ontological sense is nonreproductive. (...) the after-effect of disappearance is the experience of subjectivity itself" (p. 148).

There are numerous perspectives on the relation between performance and education, and recent studies in Brazil have explored many of them (ICLE, 2010; ICLE, PEREIRA, & BONATTO, 2017). From the point of view of what I intend to discuss in this study, I would like to highlight two aspects. The first concerns the problematization of the set of discourses, practices, and rituals that,

in their reiteration, operate to produce "schooled bodies," which reproduce the social relations of discrimination and injustice that characterize our society and have peculiar characteristics, among which we highlight the very exclusion and deletion of the body and its relations in order to develop purely "mental" and "individual" thought and learning, as discussed by Elyse Lamm Pineau (2002).

A second relevant aspect concerns observation of the events that occur in the school and the disruptive potential of the findings of such observation. Instead of an exclusive concern with the reproductive dimension associated with the evaluation of the learning outcomes, we sparked an interest in processes and their impermanence, focusing on the subjective experiences that occur and the emergence of new possibilities of understanding and relating with knowledge, others, and the world. We can, therefore, discuss performative learning methodologies developed within a collaborative rehearsal process (PINEAU, 2002).

From a methodological point of view, a performative perspective on education demands ways of investigation that facilitate finding the dimensions of the experience, the transient and impermanent character associated with educational processes. Along these lines, narrative perspectives (CONNELLY & CLANDININ, 1995; DOMINGO, 2015; LARROSA, 2015; LIMA, GERALDI, & GERALDI, 2015) and Arts-Based Research (BARONE & EISNER, 2012; HERNÁNDEZ-HERNÁNDEZ, 2008) stand out for their questioning of research paradigms that are concerned with objectivity and criteria for scientific validation; these strongly favor the use of questionnaires and other forms of data collection that would guarantee the alleged neutrality of the observer. A narrative perspective, as opposed to this narrow model of scientificity, highlights, rather than obliterates, the relationship between the narrator and the lived experience. Instead of obtaining an unproblematized measure of efficiency, the meanings of the educational experience themselves are being questioned. Without the intention of producing art in the sense that our culture understands the term, they may also help create new possibilities of experience and experimentation in education and account for their multiple meanings when they are recounted because experience, to constitute itself as such, must be narrated, and its meanings questioned and reflected on (LARROSA, 2015). Questioning an experience and seeking ways of expressing its meanings, thus creating opportunities for others to have their own experiences when relating to this expression, may provide a way to understand the arts as well as education.

PERFORMANCE AND THE NATURAL SCIENCES

Based on the same line of reasoning as the previous questioning section, considering the concept of performance and the duality between representation and event, we may be able to investigate some of the hegemonic images regarding the functioning and development of the natural sciences.

For example, philosopher of science Robert Crease (1993) presents an intriguing critique of logical-positivist empiricism by noting how, in the context of this philosophical movement, on the one hand, we seek to base all knowledge on the results of empirical experience, while on the other hand we do not pay attention to or value the very process of this experience, as if it were transparent and unproblematic. We thus reduce scientific experimentation to the theoretical representation of its supposedly definitive logical-mathematical results. By proposing an appreciation of the process of scientific experimentation, Crease, viewing it as performance, emphasizes the very capacity of this experimentation to create worlds and engage in *poiesis*. Similar to what happens in a theatrical performance, the event of experimentation is a unique moment, new each time, where something happens resulting from the confluence of theoretical representations and instruments to produce a phenomenon still to be acknowledged by those who witness it and take part in it. This perspective enables us to escape from the understanding of an experiment as the simple revelation of an already given and pre-existing reality, as well as the understanding of it as an arbitrary, unreal creation. This is a creation of a world originating from the elements configuring our current reality (theories, instruments, world views, materials, languages, affections, and desires), and it is acknowledged through our current repertoire of perception and possibilities of interpretation.

From a phenomenological and hermeneutic perspective, Crease observes the mechanisms of the production of science based on the relations between three moments of scientific practice, which he analogically relates to the activity of theater: (i) the moment of the theoretical *representation* of a phenomenon, regarded as the writing of a theatrical text; (ii) the process of presenting this phenomenon through an experimental performance, analogous to a theatrical performance; and (iii) the acknowledgement of this phenomenon by the scientific community, analogous to the recognition of the public and the critique of a theatrical performance. Based on this analogy, it can be concluded that neither is the theoretical representation identical to the phenomenon, nor does it exhaust all the complexity

involved in its experimental presentation. The presentation of the phenomenon in the experimental performance is a complex process involving the development of rehearsals, which do not yet correspond to the true presentation of the phenomenon. In the rehearsals, several adjustments are made to the instruments constituting the experiment. Moreover, they correspond to the actors of a theatrical performance in the proposed analogy. Intuition plays an important role in this concrete and material relationship with the construction of the experiment, aiming to debug it and refine it until a legitimate presentation of the desired phenomenon emerges. Acknowledgment of the phenomenon is never definitive, as it depends on the scientific community involved, the scientific and cultural context, etc. Thus, what is "seen" in a certain experiment may vary radically according to the historical context in which it occurs. In the image developed by Crease, science becomes greater, more complex, and more human than just the set of "theoretical laws" that would represent and describe how the world works and with which the common sense and positivist philosophical currents are often identified.

Sociologist of science Andrew Pickering (1995) proposes a broader performative perspective on scientific activity, in which even theoretical thinking is thought of in performative terms. The philosophical assumption for this approach originates in a critique of the representational understanding of science, and it is associated with an understanding of the world, both human and non-human, in terms of *agency,* the ability to act and undergo the action of elements of the world:

> The question is: Within the representational idiom, people and things tend to appear as shadows of themselves. Scientists figure as disembodied intellects making knowledge in a field of facts and observations (and language, as the reflexivists remind us). But there is quite another way of thinking about science. One can start from the idea that the world is filled not, in the first instance, with facts and observations, but with agency. The world, I want to say, is continually doing things, things that bear upon us not as observation statements upon disembodied intellects but as forces upon material beings (PICKERING, 1995, p. 6).

The concept of agency used by Pickering is, therefore, quite broad, applying to both the human and the non-human world. Scientific activity takes place in a "dance of agencies," in which the human element seeks to assert its will, while the non-human element resists, causes new adaptations, and demands a review of objectives, methods, and strategies by the human element. It is not only do the non-human material elements have agency; for example, one may also refer to agencies coming from social forces, and even the agency of the theoretical dimension of science, derived from the disciplining

required by the methods it adopts and uses. They may resist human attempts of translation to other domains of validity, which may generate new forms of accommodation and new human initiatives. Instead of defining a fixed cause for the development of science, whether it is the experimental work or social interests, Pickering views science as an *emerging* network of relations, a "mangle" of heterogeneous practices. From the dynamic interaction of these practices, new possibilities for tuning may emerge, enabling the creation of what we refer to as a scientific fact, including reciprocal confirmation from several practices that are properly tuned and aligned.

In spite of their significantly different forms, the points of views of Crease and Pickering, outlined only briefly above, have something in common—an appreciation of those elements constituting science, not only as a static representation of an equally stratified world, but as a dynamic and material process permeated by events. Such events invariably involve the tuning of heterogeneous elements, producing what Crease calls the performance of a phenomenon and what Pickering calls the emergence of scientific facts.

PERFORMANCE AND PHYSICS TEACHING

How can the performative understandings of education and science outlined above shape different perspectives regarding the context of the teaching and learning of the natural sciences? Several possibilities could potentially be entertained here. In this study, I propose specifically to consider the possibilities of using performative methodologies in the context of physics teaching as defined by Elyse Lam Pineau:

> In disciplinary terms, performance methodology means the rigorous, systematic, exploration-through-enactment of real and imaginary experience in which learning occurs through sensory awareness and kinesthetic engagement. In more colloquial terms, performance methodology means learning by doing and might include any experiential approach that asks students to struggle bodily with course content (PINEAU, 2002, p. 50).

Pineau compares two different uses of performance in the educational context: as a demonstration and as an investigative methodology. The first use is quite common in evaluative contexts when it is requested that what has been learned, as well as its possible applications, be demonstrated in public presentations. Nonetheless, the presentation of performance as an investigation methodology advocated by Pineau does not assume that an investigation has

previously been carried out, but rather posits the moment of performance as a privileged space for investigation and learning.

To develop the prescription of a set of procedures that may be applied and then analyze the effectiveness of the results would be deeply contradictory to the very performative perspective that we have developed. Our main concern is, after all, precisely the experience of processes in their unrepeatability and what may erupt from such events in their unpredictability. How can we, therefore, find ways of learning and investigating singular experiences? The narrative of pedagogical experiences carried out below aims to become a form of questioning and experiential thinking about the possibilities and meanings of performative methodologies in physics teaching, not a set of data for the subsequent development of a supposedly neutral and objective analysis.

I intend to develop these narratives to question three characteristics that I consider fundamental to these methodologies. Given the range of meanings associated with performance, there is a risk, outlined by Pineau in the cited article, of falling within such an extended understanding of the term that it may deflate its meaning. On the other hand, it is this range of meanings that makes it so interesting, enabling us to see several educational situations as performative events. There is an aspect of the performative methodology that does not refer, exactly, to the kind of event in itself, but rather to how we view it. Thus, a first defining characteristic of these methodologies refers to the formation of a poetic perspective on what is done, (poetically) valuing the ephemerality of the encounter event involved. As opposed to hegemonic pedagogical logic, this is a radical option for the valorization of processes.

A second aspect has to do with the presence of the body. Again, the fundamental question is the perspective from which we look at this presence or absence. Evidently, the body is always present, although its absence is often striking. The question that arises is how not to dichotomize body and thought or body and subject, how to bring to the fore not a subject that has a body, but a body-subject—a body that thinks and reflects.

Finally, a third fundamental aspect associated with the formation of performative methodologies refers to the relationship with hegemonic norms and rites. If the performative character of sentences and actions is often recognized by how they have repeatedly instituted and reproduced certain standards of conduct, our interest lies precisely in the possibility of seeing these mechanisms, enabling us to investigate and deconstruct them and to produce events that somehow cause tension regarding such norms. Consequently, the ideology that

they represent and reproduce will be questioned. Thus, we can refer to critical performative methodologies, a term used by Pineau.

How do these principles relate to physics teaching? One of the frequent accusations made against traditional physics teaching is that it builds a caricature of what scientific activity is. I believe that this accusation does not do justice to the work of cartoonists. After all, the simplified and sometimes deformed aspect of the caricature expresses a particular, critical outlook that assumes itself as such and does not seek to be acknowledged as a real, faithful, much less unique reproduction of what it represents. While trying to hegemonically dictate what scientific activity is, education does not build a caricature but rather a simulacrum with its deformed representation. It does not aim to be regarded as a representation, but as reality itself. If only education could be seen more as a caricature, assuming the fictions that it creates.

In this sense, rather than seeking to mimic scientific research, it is up to physics teaching to become aware of the diversity of particular and critical views and to develop them. This wording is still unsatisfactory, since it appears to propose a relationship that is only contemplative, found in the metaphor of the view. It also seems to suggest a focus on the need for us as teachers to create images of science that can be contemplated by the students. Rather, how can we express the will to create spaces where we can build and explore together?

This is where the metaphor of performance seems to be powerful. The proposal to perform a scientific relationship with the world provides a space of a play where we can creatively experience the multiple aspects of scientific activity without trying to equate this work with that of the professional scientist, instead building various representations of scientific activity based on our experience. Thus, we will be able to problematize it in a critical and embodied way.

In the course of discussing the relations between science and performance, we noticed the relatively recent process of enhancing the performative aspects of the scientific activity. This significantly increased the simplistic identification between physics and a certain set of theoretical laws that would describe how nature works. The in-depth historical study of any particular development of science invariably shows a complex set of heterogeneous factors (theoretical, experimental, economic, sociocultural, philosophical) involved in the processes of producing a scientific representation. While the historical reconstitution of these processes is quite interesting for developing a more complex image of science, we are not restricted to such an approach to question scientific practice. The way we relate to scientific representations and the world at present and how these

representations are updated when they are taught and learned opens up endless possibilities of performative inquiry.

As discussed in the introduction of this study, to investigate the potentialities and meanings of critical performative methodologies in physics teaching, I chose several stories from the research experiences that I conducted in a physics training course (*Teaching Projects Workshop*) and a university extension project (*Art-Science at School*). Through these experiences, I will discuss the three characteristics that I associated with this type of work—namely, the poetic experience of the ephemeral, the presence of a body that reflects and creates, and the possibilities of stressing and questioning the norms regulating school relations. Undoubtedly, these three aspects cannot be separated from one another. Each narrated experience enables reflection on all of them. Nonetheless, I will focus on them one at a time.

THE POETIC EXPERIENCE OF THE EPHEMERAL

I start with the report of a classroom practice experience (in internship classes) of a student in the *Teaching Projects Workshop:*

> *As the teacher entered the classroom, he told the students that the class would be taught by me, and I could be at ease. I saluted everyone and started. My first step was to explain to them that we would work on the following issues:*
>
> *- Is the form of the planet Earth flat or spherical?*
>
> *- Is the Earth standing still or moving? (...)*
>
> *I explained that the intention was to put ourselves in a position where we do not have a right or wrong answer, that is, that we were going to think about evidence to state whether the earth is flat or spherical, and what suggests that it is either still or moving. After that, I split the room into two teams so that each could defend a thesis: the first claimed that the Earth was flat and remained still, and the other claimed that it was spherical and moving.*
>
> *My expectation was that the first team would have more arguments and it would be easier for them to write down the evidence, but that did not happen: they were insecure when they thought they would stand up for a "lie." They worked hard to write down some arguments. The second team did not worry much. They transcribed a section of what they had in the notebook, and in no time they were defending what was "correct." (...)*
>
> *At this time, I explained how the classroom would be set up, and then they started to organize themselves. The face-to-face setting gave the debate the feeling of a dispute, and the debate started.*
>
> *Team 1 started to speak, and the main line was that nobody can feel the Earth moving, and nobody can see the curvature of the Earth.*
>
> *Team 2 said that everything was moving, and science had already proven this, even though this was not a valid argument under our agreement. It was then that this team started to*

say that the contrary couldn't even be thought of and that what the other team was arguing was not the right thing.

Team 1 started to feel embarrassed, since they would not admit to thinking of the Earth as still, so I intervened. One of the boys on the team was throwing an eraser up and grabbing it with his hand, so I asked him to do that again for everyone to watch. I realized that the students imagined that I would complain or criticize that attitude and that I would not use it as a part of the class. He then repeated the movement, and I questioned:

- If the Earth really moves, why does the rubber exactly fall in his hand, not a little to the side?

The silence was total. A girl said, "Now all we need to hear is her saying that the Earth is still," and another student argued that "that is because the movement of the Earth is very slow." However, a third student glanced at a note in his notebook and found that the speed of the movement was approximately 1500 km/h, so that argument was not valid.

The intern's intervention transformed the meaning of an attitude, initially considered "a mess" and a "disruption," into an argument against the motion of the Earth. It confounded the students' expectations in two ways: it stood for a "wrong" thesis and did not reprimand a "wrong" attitude but rather included it in his/her discourse. The "total silence" following this act is also quite significant, since it indicates the emergence of an unexpected situation, questioning our ways of perceiving the world and relations and making headway in creating new forms of perception.

Teaching work is filled with moments like this in which "something" takes place, like moments of irruption. Nevertheless, there is no way to either plan or predict them, and we do not often know how to take advantage of these moments when they happen to occur. Certainly, it is possible to plan to expand the possibilities of these events. All the organization that the intern established for the non-dogmatic way that students dealt with knowledge and how the bodies related to each other in the space and time of the classroom made headway for new events. Moreover, there is teaching training that does not concern itself with previous planning but with the state of attention and listening at the present time and the relations established in space. How can a teacher prepare for the state of "readiness" that these present-time relations demand?

We do not sufficiently treasure the occurrence of events like this. They bring us a certain inner happiness, which sometimes motivates us to comment on them with a colleague and soon forget about them. After all, there is no measurable learning outcome produced by such moments. To treasure the process in teaching work implies treasuring what cannot be measured, what cannot be objectified, what does not generate a product, but passes, just as any event that takes place in time does. What qualities do we aim

to achieve in the educational processes in which we engage? This is about qualities impossible to reify. Otherwise, we would again be dealing with products, not processes. They characterize a real encounter, a singularity, whose transformative potential originates in a certain quality of relation and involvement.

The following is a report of mine on relationships in the *Teaching Projects Workshop:*

> *Our meeting did not take place in a physical configuration of chairs and tables, but on a floor covered by tiles made with EVA, without chairs and surrounded by shelves with low-cost scientific experiments (the space used for a science club was adapted as necessary). The absence of chairs and tables exposes us in a way that we are not accustomed to, at least not in a school situation. Although I was used to this configuration in other contexts, transitioning to the context in which I was a physics teacher made me move from a situation of habit and comfort to another one in which I felt a little as if I were naked. Something similar happened with the students, too. This resulted in some discomfort, but also situations of great pleasure and discovery. I only realized some of the most important things that happened in this study much later, when someone would recall a memory of an interesting situation, something that moved them.*
>
> *An event I had already forgotten became remarkable for me when, at the end of the school semester, a student commented on how important that event was for him. I had proposed a theatrical improvisation game in which we all stood up and formed a circle, while a player entered the center of the circle, creating a situation in which we were in a fictional place that would move. When someone in the circle believed they had discovered "where" the player in the center was, he had to enter the scene and complement the action of the first player, but without ever "telling" where he was. Subsequently, other players would have to enter the scene and follow the same rule. This exercise was mainly aimed at discussing the law of inertia and relative movement, stimulating contact and non-verbal dialogue among the players based on a fictional situation. Furthermore, it was meant to stimulate spontaneity in a personal state of exposure, which the student group is not very used to.*
>
> *In one of these exercises, a player proposed the situation of a moving boat. Other players entered and composed the action; one of them was a fisherman who had caught a fish and was trying hard to pull the fish from the water in an action that took place in my direction. Without thinking too much, I also entered in the scene in the role of the... fish. It was with surprise that at the end of the semester, I heard about how that moment was important from a student who had felt uncomfortable with this type of exercise. He said that everyone at that moment stopped for a second in surprise, then looked at each other and continued the game. From then on, he did not feel so afraid of exposure to situations that he considered ridiculous. After all, if even the teacher put himself in this situation, we were all literally in the same boat.*

Although the events passed by, they created a lasting memory. Thus, an important way of appreciating them is to narrate them, assigning meaning to them while talking about them. The narration cannot freeze the event, but it transforms it, making it reverberate, constituting it as a conscious experience. This enables those who experienced the original event and those who did not to create new experiences about them.

In the quote to which I have already referred, Pineau asked how "a course [would feel] if the syllabus were thought of according to a collaborative rehearsal model." In such processes, it becomes increasingly obvious that we have no control over our actions, as they are configured through a network of interactions and influences. In their unpredictability, situations promote learning. My decision to participate in that scene was not related to any pedagogical objective. It was a mere consequence of the configuration established there. I could even say that it was not a decision that was up to me at that moment. It was a demand of that configuration, for which I was *available*. It is likely that the most intense learning that moment offered was not linked to any of the themes that I intended to develop through that game, but to the multiple possibilities of the teacher-student relationship, especially when our bodily presence is explicitly included. Since that was a teacher training course, I stuck to the syllabus.

THE BODY THAT REFLECTS AND CREATES

ESTRANGEMENT

How does one investigate, think, and learn through the body? A first obstacle to this type of proposition is related to an attitude of distrusting the senses that is deeply rooted in rationalist thought traditions. It often seems as if the testimony of the senses is misleading, and might only be used reliably if exercised under the control of reason. For example, when justifying why we should be suspicious of the perception that the Earth is standing still, Galileo compares this type of perception with what we experience when observing the moon while walking around the city:

> I would like to remind you of a phenomenon that you have surely seen a thousand times. This may help understand how others can easily be fooled by the simple appearance, that is, the representation of the senses. This phenomenon gives the impression to those who walk on a road at night that they are being followed by the moon at an identical pace, while they see it hover the rooftops where it appears, just like a cat that, while actually walking on the tiles, would stay behind them: it appears that, when reasoning would not intervene, vision would mostly be deceived (GALILEI, 2004, p. 338-339).

Without the "filter of reason," perception may mislead. However, if there is something that the science of the twentieth century clearly teaches us, it is that the "filters of reason" may also mislead. Moreover, as discussed by Gaston Bachelard (1974), older

scientific reason frequently remains an epistemological obstacle to the possibility of creating new scientific images of the world and a "new scientific spirit." Thus, instead of a dualistic polarization between misleading bodily meanings and the rational thought that would clarify them, we can acknowledge how the forms of perception are already associated with certain forms of understanding, as well as how the need to overcome certain forms of perception and understanding sometimes arises. Perception is already a way of understanding, and understanding is also a form of perceiving the world.

Thus, trying to challenge and denaturalize some perceptions and seemingly inevitable and natural understandings is a strategy often used to make us aware of the constructed, changeable character of what once seemed rigid and eternal. We may reread the previous passage by Galileo and his inquiry about how we concretely see movement as a work of estrangement and denaturalization of the perception and understanding of the movement. By doing this, the existence of a set of implicit hypotheses of what previously appeared to be a direct and immediate reproduction of the real is revealed. This builds the possibility of transforming such hypotheses, and thus the perception and the understanding of the movement.

German playwright Bertolt Brecht (1978) developed several theatrical strategies to produce "estrangement effects" that would enable him to challenge the capitalist relations of social exploitation through his theater, unveiling its historical, constructed, and thus changeable character. To achieve this, the scenic explanation of theatrical conventions involved in a theatrical representation enabled him to break a spectator's illusion of witnessing a real event. This would remind him that he is before a stage, pretending to be certain characters at fictional times and places, using specific artifices and conventions. Highlighting the artificial, conventional, and fictional character of a representation leads a spectator to distance himself and think about the also artificial and constructed character of the reality represented therein. This may make him wonder about its reasons for being and possibilities of transformation.

The analogy suggested herein refers to the importance of acknowledging the hypothetical, fictional, constructed, conventional, and changeable character of human constructions, whether they are a theatrical representation, a physical theory, or even a social structure. As pointed out by French physicist Jean Marc Lévy-Leblond (2001), scientific constructs, considering their hypothetical foundation, are permeated by fictions:

> *Rejecting fiction is meant to insure the positivity of scientific knowledge against the risk of uncontrolled imagination. Yet the drafting of hypotheses — that is, precisely, fictions in Latin — is one of the first endeavors of scientific activity. How, then, can we discriminate between hypotheses that we should dismiss as irrational fantasies, and those that we posit right at the outset of our investigations? Could it be that science paradoxically offers the best proof that fiction can lead to facts? (LÉVY-LÉBLOND, 2001, p. 573).*

The possibility of challenging physical theories using theatrical improvisation games is an invitation to engage in a bodily manner with scientific reflection, adding a fictional dimension to this interaction. This will enable us to appreciate the constructed, symbolic, created, and creative character of the theatrical game and of physical knowledge.

> *The first memory that I have of experiencing, as a teacher, this type of work must have occurred in 2006 or 2007. I remember proposing theatrical games of work with imaginary objects. By carrying the object, using it in some way, remaining in a wheel with the others, one of the students would throw it to another colleague, who would crush it and form a new object from the invisible matter in his hands. Each object should also have a weight, and this was perceptible by the way we carried it, manipulated it, threw it, and received it. I tried to introduce physics in this exercise by adding the following instruction: "We are on the moon" or "we are on Saturn," etc. Thus, I wanted to discuss the difference between the mass and the weight of a body, based on sensitivity and bodily imagination. I intended for us to reach the perception that once we changed planets, the weight of the object would change, but the impulse that we needed to provide it with when throwing it and the kick we received when grabbing it did not. The idea was not to reach this conclusion rationally and then direct action, but on the contrary to verify how bodily imagination would direct action, and then discuss the question based on how we act.*

The experience of a bodily relationship with the theatrical conventions aimed to illuminate the meaning that the scientific conventions attributed to the mass and weight of an object.

As time passed by, the idea of investigating physics themes using theatrical games enriched itself. The concept of estrangement, in particular, became increasingly relevant. Figure 1 shows a photograph of a theatrical game in which students were asked to construct a "subversion of verticality." The image shows that the players strove to maintain their heads in an orientation consistent with the illusion of verticality that they were creating while showing their artificial and conventional character. With this type of game, we explored the scientific hypothesis (fiction) of an isotropic space (a geometric space in which all directions are equivalent), and we highlighted its implausibility on a planet where the vertical direction is clearly different from the others. Simultaneously, the exploration of the relativity of verticality (on a spherical planet) enabled us to construct new perspectives on the evidence of the sphericity of

the Earth and the nature of gravitational attraction. This work was developed using several activities in which the bodily presence of the reflecting people was always an important focus (Crochik, 2013).

FIGURE 1. Picture of a theatrical game played in the classroom. Photograph extracted from a shoot carried out in a classroom by many of the students.

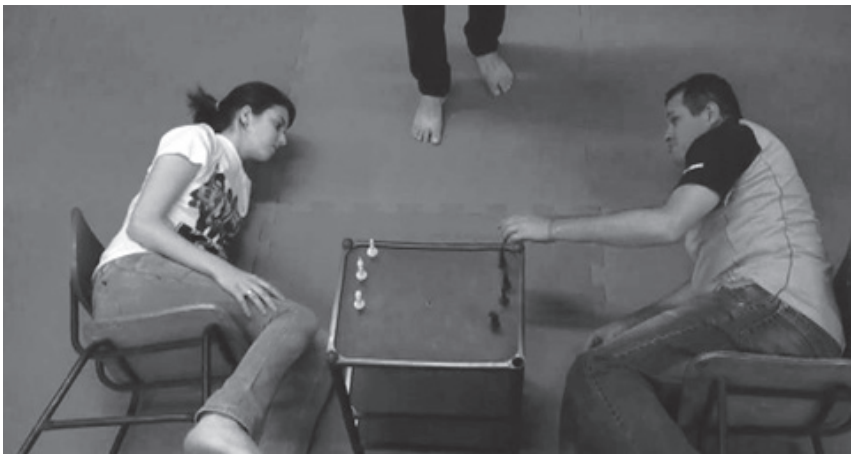

FIGURE 2. Picture of a theatrical game played in the classroom. Photograph extracted from a photo shoot carried out in the classroom by many of the students.

The relativity of motion and its relationship with the scientific debate over the movement of the Earth was also investigated, adopting similar strategies (Figure 2). In this way, I believe, we construct with our thinking bodies problematizations of our perceptions and conceptions. This enabled us to explain the multiple hypotheses and conventions involved in the structuring of what is referred to as physical space, revealing it as a human construct, rich with historicity.

DEEPENING OF THE SENSITIVE PERCEPTION

> The body feels from inside its outside and feels its inside from outside. Feeling itself, the body reflects. For the first time in the history of philosophy [with the work of Merleau-Ponty], thanks to the work of art, we found that reflection is not a privilege of conscience, but that this collects an older reflection that teaches one to reflect upon bodily reflection (Chauí, 2002, p. 179).

A second perspective experienced by the possibilities of bodily investigation of science concerns the importance of making the act of perceiving more sensitive and subtler. In the work of Galileo, we can again find historical examples of this perspective. For example, his work observing the moon, in which he recognized its craters, depended on a new instrument of observation (the telescope), as well as a sensitive deepening of the experience of looking, seeing in the play of light and shadows present in this experience of two-dimensional observation the existence of an uneven three-dimensional surface, just as the paintings of the same era did. Therefore, an important part of his astronomical investigation depended on his contact and dialogue with painters, particularly Cigoli (Edgerton, 2006; Reeves, 1997).

In the Art-Science at School project, we created a few interventions, called *"Body Laboratory,"* the main idea of which was to transform the very subject that experiences it into an *"experimental object."* The subject would continue to simultaneously be the subject who studies. The sensitive and creative act of perceiving oneself in the proposed situations corresponded to the most important learning moment.

One of these proposals explored the recognition of the multiple pendulums found in our bodies. When associating the movement of our legs with the movement of a pendulum (Mainieri & Helene, 1984), we can relate walking speed to the period of the pendulum, which depends only on its length and the value of gravitational acceleration. This relationship is interesting because it enables us to estimate the speed of several animals according to the size of their legs/paws and understand what would occur when a human walks

on the moon. The less the acceleration of gravity, the slower the movement of the pendulum; therefore, a natural walk—carried out without excessive effort—would also be slower With the image of the leg as a pendulum, the students were encouraged to experimentally analyze the effect of an increase in gravity, simulated through rubber bands tied between the feet,[1] which intensified the force with which the moving foot is pulled "down." Below is a passage from a report by one of the students who proposed and performed the intervention:

> *We asked if they knew what a pendulum was, and we realized that the large majority of them already knew or at least had a vague idea of it, but we showed one anyway. That was the moment when it became clear that the students were not as naïve as we had imagined, and that more specific physics terms would make sense to them. It did not take long for the groups to say "gravity." After this stage, we asked if they recognized the pendulums in their environment. To our surprise, they started with those found in the human body, something that was to be asked later. As they had already skipped a stage, we asked them to make the pendulums in their bodies oscillate and compare that with what was previously shown at the beginning of this stage. (...)*
>
> *After that, we asked them to think of a way of simulating the effect of the increase in gravity, and we obtained answers such as "increase the mass of the planet," "decrease air resistance," and some other things that would not be feasible. That was when we showed them the rubber bands, and they started to come up with ideas. Before that, we asked them to walk without the rubber bands so that they could feel what the walk was like and have a stronger perception of the effect that the rubber band produces. When we handed them out, the school patio became a party place: the students started walking, but soon they ran around racing each other and created new ties with more rubber bands. They were so excited that even the two PIBID teachers who were watching the activity asked to join in. After 20 minutes, we asked them to go back to the groups.*
>
> *They were able to realize what the rubber band was doing to their legs; we only gave them a few tips and tried to explain why the elastic force simulated the effect of an increase in gravity. (...)*
>
> *I believe the activity achieved a positive outcome. We challenged our own preconceptions about public schools. Considering what we asked of them, we managed to make a good association between art and science, using the movement of the body and making them feel it. There was a lot of discussion on everything they were feeling, and we tried to give a physical meaning to all of that. Everything happened in the context of the school, making them interact with the subject matter in another way, and there was a different interaction between the teachers and the students.*

In this report, the moment when the schoolyard turned into a party deserves to be highlighted. The body is so often excluded from the school learning process that the moment it was included and released to experience with itself, there was an intense outpouring of life that had until then been stifled, to the point that it infected all who witnessed it.

In addition, from a physics point of view, a sophisticated set of reflections takes center stage. Some of them are as follows: (i) the ability to model a complex movement in terms of a simple pendulum,

an extremely important operation to construct a physical way of thinking of the world, which is nearly absent in the traditional way of approaching physics in high school—this approach usually presents ready-made models to students; (ii) investigating the effects of a physical quantity (the acceleration of gravity) on the value of another (the walking speed); (iii) the possibility of simulating this study in an experiment using rubber bands; and (iv) finally, the possibility of investigating the proposed models and interactions involved with the body, feeling the effect of gravity and the interaction between the rubber band and the movement of the legs. This may be split into different stages, enabling variations such as running as well as variations in the size of the steps, and then followed by a debriefing on the experience, thinking both through it and from it.

It is important to note that the modeling does not occur here as an intangible, purely mental process. The model of a pendulum is used to deepen the sensitive perception of the movement of the body itself when walking, enabling the exploration of different forms of walking and moving. There is a two-way relationship, a tuning between the modeling practice and the movement practice, in which the modeling transforms and raises awareness of the movement and the movement defines the limits and offers "experimental results" to the modeling practice. Physics and dance move closer together in this intervention.

In short, it seems that the perspectives of producing estrangement toward the forms of perception and understanding and developing a sensitive deepening of bodily perception and comprehension make an interesting complementary pair. This enables us to think of and devise strategies to develop ways of reflection and learning that do not dichotomize mind and body.

PLAYING WITH THE RULES

> The metacommunicative signal "this is play" temporarily releases, but does not disconnect, us from workaday realities and responsibilities and opens up a privileged space for pure deconstruction and reconstruction (CONQUERGOOD, 1989, p. 83).

The word *play* involves many possible meanings. For this reason, the relations in a classroom may become closer to the concept of play in many ways, with many implications. A first aspect of this approach is the creation of an area of freedom and creation that is organized according to certain rules—the rules of the game. The rules of the game set up a wide space of possibilities so that the process can actually develop into a game, not just a repetition of expected and anticipated behaviors.

However, not every game has rules that are known or defined. For instance, as occurs in children's games, sometimes the very rules of the game are in play and can be transformed throughout their development. Furthermore, the distinction between play and "real life" is not always clearly established. Sometimes we take part in a play established by others unwillingly and unconsciously, which Richard Schechner (2002, p. 106) calls dark play, as in the *Invisible Theater* of August Boal. The "real world" can be metaphorically thought of as a game. In this metaphor, the scientific activity (the natural sciences herein) is associated with the effort of discovering the rules of this game, which are more commonly thought of as fixed (the "laws of nature," which may also have a probabilistic form instead of a deterministic one). Nonetheless, in some cases even the genesis of these rules may be put into question, as happens in the context of cosmology.

It is in this more open and undefined meaning, regarding the definition of the rules and the limit between fiction and reality, that the concept of *play* comes closer to a critical performative perspective in education. Apparently, if the rules of the game are not sometimes put in play and the teacher remains stable in the role of the one who makes the rules and ensures their correct enforcement without risking playing the game, we lose an aspect offered by the artistic tradition of performance: searching for the cracks where the established norms and rites can be challenged, as well as the relations of power and the ideology they implement and represent.

Interestingly, in the *Art-Science at School* project, two interventions created and performed by the same students aimed to question "the play" through which science aims to allegedly "discover the rules of nature." Nevertheless, since they were carried out at school, they led their creators to have to deal and play with implied rules defining the relations between teachers and students.

> *The first intervention, called Codes, Transformations, and Perceptions, aimed to explore the relationship between the discovery of the rules of a game created by scholarship holders and scientific research, understood as the effort to discover the "world game" rules. In a state school, the scholarship holders of the project presented a series of experiments whose manipulation led to visual effects produced by various physical phenomena. Additionally, they integrated the presentation with their bodies and established a code according to which different actions of the school students in the manipulation of the experiments led them to produce certain sounds through the veiled operation of musical instruments and sound sources. Thus, the intervention created a combination of "real" effects—sometimes apparently by magic—of physical experiments and "surreal" effects that also seemed to be caused by the operation of the same experiments. Thus, the intervention engaged the students in the discovery of the play of causes and orchestrated effects. They had fun while distinguishing the real mechanics of the experiments exposed from the surreal play proposed by the performers who constituted the action.*

> *The intervention was performed twice during the Science School Fair. In the first one, the students were already expecting a presentation that had been announced by the school. Disappointed with the observation of a set of experiments with no explanation, they did not build interest in investigating that event. Finally, they simply triggered all the handles they saw in front of them quickly and mechanically, and then they left. After this first "fracas," the performers organized themselves to start their intervention again in the night class before the students arrived at school. They remained there, together with the set of experiments, as part of the school landscape, without any notice, hoping to be discovered. Each student who arrived then interacted with a part of that installation. Little by little, a collective curiosity grew about what it was. Every small discovery that was produced was then a source of joy and pleasure. The discovery of a specific action that blew a horn in a seemingly automatic way started a comical play of repetition. The student operated the mechanism and observed the seemingly mechanical movement of the performer's playing the horn, making explicit the ironic meaning of the intervention.*

In this investigation activity, it was up to students to unravel the underlying mechanisms and logic of that silent but expressive reality. It did not explain itself, nor did it indicate what was supposed to be done. However, it remained waiting to be discovered, as a metaphor of the scientific research work (at least, according to the epistemological convictions of the intervention creators). The intervention proponents created ways of leading the students to somehow relate to the installation, without explicitly guiding what "must be done," allowing the game rules to be defined from the play itself. The students acted on the installation that was constructed, and the installation acted on the students, leading them to gradually find the codes that would enable them to relate to it.

The interaction logic *emerging* from a given arrangement of agencies (in an analogy to Andrew Pickering's idea of performativity in science) clearly appeared in the second intervention, called *Rhythmic Sensorial Transformer:*

> *The scholarship holders devised an electronic musical instrument (a styrofoam box attached to some sensors and a loudspeaker), operated by putting the operator's hands close to or far from the instrument sensors without physical contact. An Arduino microprocessor converted the distance information picked up by the sensors into various frequencies of sound of a duration and pattern of variable repetition. The way the students were exposed to this installation was thought of in order to allow them to discover and invent their way of interacting with the object. This would avoid the habit of explaining and normalizing action: It was put in a corner of the school patio with no announcement, waiting to be discovered. There was a banner reading "touch without touching" next to it. When the intervention video was watched, it was fun to notice how the school students discover the instrument and start to actually make music with it, creating and dancing to different rhythms, as well as the intervention creators' expression of surprise when they found that the play they had proposed was working: "Hey, people are really making a sound, man! The guys are making music; can you believe that?" After that, some volunteer students*

participated in developing a workshop to use the Arduino microprocessor and discussed how the sensors and mechanical waves worked. They enabled the sensor to "notice" from a distance, providing means for the students to create their own contraptions.

FIGURE 3. Intervention of the Art-Science Project at School: Rhythmic Sensory Transformer. Photograph extracted from a video made by Fernando Cezar M. Cesar and Bruno Chida.

By not normalizing the action, the intervention subjects also took their own proposed risks in the play, and thus lived the expectation and joy of their participation. For a short period, the center of the agency was neither the intervention proponents nor the students, but the musical instrument they created. It provided tuning between sounds and movements from a play of pre-programmed sound answers with the students' participation. We might wonder whether the students would have actually explored the potentialities of the instrument they built if they had only been introduced to it

by an explanation of how it operated instead of the discovery game they played. The tacit way the game was constituted promoted a type of relationship based on the freedom to act and interact, not the obligation to follow orders. To achieve this, intervention proponents investigated a great creative effort to make the play highly attractive and inviting. The intervention was configured as an invitation to a workshop where the play with electronic components could be further examined, not only involving an interaction with a pre-programmed black box (or in this case, white), but also the possibility of opening this box and developing new ways of interaction with the sensors.

When creating these interventions, physics teacher-training students develop their sensitivity to a relationship established at the present time and, to some extent, unpredictable; however, it has a logic, a structure enabling one to play, providing pleasure in each encounter. Regarding the kinds of relationships that may be established among teachers, students, and scientific experiments, instead of establishing a relationship in an authoritarian, inhibiting way based on what we believe is possible, correct, and more pedagogical, we should allow the relationship to freely establish itself in a sensitive and creative manner. The fact that we as teachers often engage in more authoritarian and closed dynamics is due to the lack of a repertoire for dealing with other possibilities of encounter.

CONCLUSIONS

At first sight, the perspective of learning physics in a performative way may seem very abstract, implausible, or only anecdotal, unable to ensure the effective learning of this subject. Considering this issue, I hope that we showed a relatively wide range of possibilities of physical learning through performative processes, in which a thinking, playing-with-situations, creative body is involved.

Moreover, it must be pointed out that the use of differentiated methodologies does not aim to teach "the same thing" in different, more or less efficient ways. Rather, it aims to shed light on what learning, science, and more specifically, learning physics may signify. Based on the pedagogical concepts discussed above, we jettison a dogmatic view of scientific activity focused only on scientific products and reified in a few decontextualized mathematical laws. These rules are devoid of their historical construction process and the complex relations in the process of modeling phenomena. On the contrary, we

seek to value the historical processes of scientific construction and science learning, thus making headway in playing with the multiple agencies involved therein, acknowledging the hypothetical and fictional dimension of scientific thought, the importance of debating and contrasting ideas, the wealth and complexity of the modeling processes, the dance of agencies involved in the relations between the experimental devices and the material world, etc. The perspective presented herein is an open learning space to create new experiences of relations between the subjects who seek to know, learn, and teach, as well as experiences of relations with scientific practice. We sought to contribute other viewpoints, present other images of science, and develop other ways of forming a scientific relationship with the world and an educational relationship with the school.

Evidently, this type of methodology—like any other—does not exhaust the possibilities of understanding the phenomena studied. However, it enables an incarnated type of understanding very often absent in other ways of learning. It seems as if classroom education must be supported in the relationship between the subjects in collective forms of learning, thus responding to an urgent need in an increasingly virtual world, where physical and bodily encounter spaces are increasingly rare.

The experiences with these methodologies have had a marginal role in the school training processes so far, whether they are presented as an elective teacher training course or as the production of a few interventions in basic education schools. We are clearly far from the Pineau perspective of integrating performative methodologies into the curriculum "similar to how writing has been articulated." This marginal aspect makes sense when associated with interventions focused on causing tension and shifting hegemonic forms of pedagogical relations. Despite this scattered, marginal presence, its formative role must be taken into account in teacher training. It develops sensitivity to present-time encounters, dynamics that are not limited by hierarchical, authoritarian relations so as to promote autonomy and risk-taking in proposing new strategies, and a less dogmatic relation to scientific knowledge. These interventions sought to create practical spaces of rehearsal and reflection in basic education, involving scholarship holders, interns, students, and teachers and regarding new possibilities of relationships between subjects, the school space, and scientific knowledge. In spite of an educational policy vehemently opposed to the principles defended herein, I hope that such experimentation and reflection may find a space to come to fruition.

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NOTES

[1] The rubber bands simulate the effect of the gravitational acceleration so that the role they play in the dynamics of the oscillatory movement is the same as the gravitational force, namely, restoring the situation of equilibrium.

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