

Status of the Question of Experimentation in the Online Context: What do the Events in the Physics Teaching Field Say?

Estado da Questão sobre a Experimentação no Contexto Online: o que Dizem os Eventos da Área do Ensino de Física?

ISSN 2177-8310
DOI: 10.18264/eadf.v11i1.1371

Daiane Rattmann Magalhães Pirez^{1*}

Anahy Arrieche Fazio¹

Franciele Pires Ruas¹

Rafaele Rodrigues de Araujo¹

¹Universidade Federal do Rio Grande – FURG. Av. Itália, km 8, Bairro Carreiros - Rio Grande – RS – Brasil.

*daiianepirez@furg.br

Abstract

Abstract. The research aimed to understand the State of the Question of experimentation in Physics in the online context through events organized by the Brazilian Physics Society and by the Brazilian Association for Distance Education. For this, we analyzed 40 articles through two categories: “Didactic tool: the potentials and limits that cross the use of the virtual and face-to-face experiment in the teaching of Physics” and “Online teaching spaces and strategies in the training of physics teachers”. We concluded that the integration between virtual and real resources is the realm of face-to-face, distance or hybrid modalities, constitutes as a way for the classes to become more interactive, leaving the teacher to use them in the creation of activities that expand collaborative actions in the classroom.

Keywords: Experimentation. Online teaching. State of the question. Physics teaching.



Received 04/01/2021
Accepted 29/03/2021
Published 30/03/2021

HOW TO CITE THIS ARTICLE

ABNT: PIREZ, D. R. M. *et al.* Estado da Questão sobre a Experimentação no Contexto Online: o que Dizem os Eventos da Área do Ensino de Física? **EaD em Foco**, v. 11, n. 1, e1371, 2020.
doi: <https://doi.org/10.18264/eadf.v11i1.1371>

Estado da Questão sobre a Experimentação no Contexto Online: o que Dizem os Eventos da Área do Ensino de Física

Resumo

A pesquisa buscou compreender o Estado da Questão sobre a experimentação em Física no contexto online através de eventos organizados pela Sociedade Brasileira de Física e Associação Brasileira de Educação a Distância. Para isso, analisamos 40 artigos por meio de duas categorias: "Ferramenta didática: as potencialidades e os limites que atravessam o uso do experimento virtual e presencial no ensino de Física" e "Espaços e estratégias didáticas online na formação de professores de Física". Significamos que a integração entre recursos virtuais e reais no âmbito da modalidade presencial, a distância ou híbrida, constitui-se como um caminho para que as aulas se tornem mais interativas, cabendo ao professor utilizá-las na criação de atividades que ampliem as ações colaborativas em sala de aula.

Palavras-chave: *Experimentação. Ensino online. Estado da questão. Ensino de física.*

1. Introduction

We have witnessed an accelerated technological development with the expansion of various digital resources and interfaces, which has motivated numerous transformations in our society. Students and teachers are constantly immersed in this so-called virtual world. In this sense, the teaching and learning processes need to follow the transformations that have been taking place in our society, generated by the development of technologies and media. In the area of nature science teaching, it is already possible to perceive a movement of both teachers and undergraduates in order to integrate different tools and technological resources into their practices.

Allied to this issue, we have the fact that for some subjects experimental activities still show themselves as a challenge in thinking and doing when the subject refers to the online context. However, Heckler *et al.* (2013, p.7) state that the "[...] operating in experimentation in online sciences is a way to overcome insecurity regarding this appropriation and linearity of learning times."

Transposing these challenges, the appropriation of technological tools characterizes a scenario that goes beyond instrumentation and enables the study of nature phenomena on an epistemological level, breaking with the idea of experimentation with an exclusive focus on proving theories, with the use of watertight scripts. With this, we speak of an experiment that values research and has collaborative environments as a means of problematizing and dialoguing about knowledge.

Thus, we explain that articulating experimentation and online teaching is emerging and that it presents a series of discussions in the field of Education. Thus, the aim of this article is to understand the State of the Question on experimentation in Physics in the online context in national and international events in the areas of physics teaching and distance education. To this end, we held the State of Question in the national events in the area of physics teaching organized by the Brazilian Society of Physics and an international event organized by the Brazilian Association of Distance Education, in order to understand what is shown about discussions on this topic in the Brazilian scientific community.

2. State of the Question: The methodological path

For the realization of qualitative research, which aimed to understand what is shown about experimentation in physics in the online context, we used the State of Question as research and analysis methodology. This methodology aims, according to Nóbrega-Thierren and Thierren (2004, p. 8): “Delimit and characterize the (specific) object of investigation of interest of the researcher and the consequent identification and definition of the central categories of the theoretical-methodological approach”. With this, our research corpus took place in national events in the area of physics teaching, held by the Brazilian Society of Physics (SBF) and an international event related to Distance Education held by the Brazilian Association of Distance Education (ABED). Thus, three events were analyzed: The Research Meeting in Physics Teaching (EPEF), the National Symposium on Physics Teaching (SNEF) and the International Congress of Distance Education (CIAED).

The State of the Question “[...] it then configures the clarification of the position of the researcher and his object of study in the elaboration of a narrative text, the conception of science and its epistemic contribution in the field of knowledge” (NÓBREGA-THIERREN; THIERREN (2004), 9). Thus, we focus our gaze on the events mentioned above, in order to seek contributions to the theme in question. The period of analysis of these events was 20 years, so the investigation occurred in events held from 2000 to 2019, with the following descriptors: Online; Distance education; Experimentation; Experimental Activities; experiment.

In this first movement of analysis, in the events that had the annals available, we found 263 articles. These texts contained the descriptors in the title or in the keywords or in the summary. However, as our object of investigation takes place around online experimentation in physics teaching, after a second movement of analysis, that is, a careful reading of the selected writings, we noticed that some did not fit the researched theme. With this, for the qualitative analysis, there were 40 articles left, which we present in Chart 1.

Table 1: Articles selected by event with coding

Event	Year	Author(s)	Code
SNEF	2017	SANTOS, J. S. dos; et al.	A1
		GOMES, C.; et al.	A2
		EVANGELHO, B. V do; SANTOS, R. C. M.	A3
		SIM, A. A. do; MONTEIRO, M. A. A.	A4
	2015	XAVIER, A. P.; VERTCHENKO, L.; AMANTES, A.	A5
		MORO, F. T.; NEIDE, I. G.; VETTORI, M.	A6
		IWAMOTO, H. K. S.; CAETANO, T. C.; SILVA, A. P. da	A7
		SILVA, J. C.; et al.	A8
		LEAL, A. C. da S.; et al	A9
		SALES, G. L.; LEITE, E. A. M; VASCONCELOS, G. H. L.	A10
	2013	MONTEIRO, M. A. A.; et al.	A11
		SILVA, N. C. da	A12
		DUTRA, L. de. M; BARROSO, M. F.	A13
		MONTEIRO, J. C. B.; et al.	A14
		NEVES, J. A.; et al.	A15
	2009	LOPES, R. P.; et al.	A16
		PESSANHA, M. C.R.; COZENDEY, S. G.; SOUZA, M. de O.	A17
	2007	SILVA, T. da.	A18
		AGUIAR, M. S.; CASTRO, R. M. de	A19

	2005	GAMA, C. F.; PAZÊTO, F.; COUVEIA, R. C.	A20
	2003	SOUZA, G. L. de; et al.	A21
		KOEHLER, L. F.; MAZER, H.; BRINATTI, A. M.	A22
EPEF	2018	NEIDE, I. G.; GAMA JÚNIOR, R. C.	A23
		ALVES, N. F.; NEIDE, I. G.	A24
		PONTONE JUNIOR, R.; PAULA, H. de F. e	A25
	2016	SENA, M.; SILVA, R.; MARTINS, A.	A26
	2014	CAETANO, T. C.; SILVA, A. P. da; MOREIRA, C. C.	A27
		DUARTE, M.; JAMMAL, N.; JUNIOR, E. da C.	A28
	2012	HEIDEMANN, L. A.; ARAUJO, I. S.; VEIT, E. A.	A29
		AGUIAR JUNIOR. O; VILLANI, C. E. P.	A30
		SILVA, C. F. da; et al.	A31
	2008	SILVA, M. J. V. T. da; ANGOTTI, J. A. P.; MION, R. A.	A32
		STEIN-BARANA, A. C. de M.; LOPES, D. P. M.	A33
		SILVA, T. da; BARROSO, M. F.	A34
2004	CARVALHO, D. L. de; DUARTE, J. L. M.; PACCA, J. L. de A.	A36	
	SCHUCK, A. F.; SERRANO, A.	A37	
CIAED	2015	MOREIRA, R. M.; MANTILLA, S. P. S.	A38
	2005	MENDES, M. A.; FIALHO, F. A. P.	A39
	2001	SOUZA, C. P. de; COSTA FILHO, J. T.	A40

Source: prepared by the authors

In Chart 1 we explain the second movement of analysis performed, in which from the initial corpus we highlight the articles that discuss in some way the online experimentation in physics teaching. With this, we again carefully read the 40 selected articles in the search for relationships, in a categorization process. According to Nóbrega-Thierren and Thierren (2004, p. 11) “[...] it is precisely this process and the material/text produced in this phase that provide the elements to identify and define the references and categories essential to data analysis in the desired approach.”

In this perspective, with the categorization process we find two categories that express the relationships of the analyzed articles, which are: “Didactic tool: the potentialities and limits that cross the use of the virtual and face-to-face experiment in physics teaching” and “Online didactic spaces and strategies in the education of physics teachers”. The distribution of the articles in these two categories is expressed in Table 2.

Table 2: Distribution of articles by category

Didactic tools: the potentialities and limits that cross the use of the virtual and face-to-face experiment in physics teaching	Didactic tools: the potentialities and limits that cross the use of the virtual and face-to-face experiment in physics teaching
A1, A2, A3, A4, A5, A6, A7, A8, A9, A11, A12, A13, A15, A16, A18, A19, A21, A22, A23, A26, A27, A28, A32, A34, A35, A36, A37, A38, A39, A40	A10, A14, A17, A20, A24, A25, A29, A30, A31, A33

Source: prepared by the authors

As shown in Table 2, the selected articles were distributed into two categories emerging from the analysis. With this, we will discuss the results in which we perceive in the first category “Didactic tools: the potentialities and limits that cross the use of the virtual and face-to-face experiment in the teaching of Physics” a range of tools, didactic artifacts and methodologies addressed in different theoretical-practical

contexts. We also seek in this category the potentialities and limitations, based on the experiences reported in the studies, which involve the use of different forms of experimentation.

In the second category “Spaces and online didactic strategies in the training of physics teachers” we will discuss how the initial and continued training of teachers requires spaces that allow the discussion, reflection and debate of topics that permeate teaching, culminating in the improvement of practice and consequently teaching and learning. Therefore, in the next topic we will bring these discussions permeated in these themes emerging from the process of analysis of the State of Question.

3. Discussion of results

3.1. Online Teaching Spaces and Strategies in the Training of Physics Teachers

Thinking about the formative spaces as pedagogical potential, experimentation can be an allied didactic strategy in the context of the teaching of natural sciences, especially physics. In a perspective that goes beyond the proof of theory in practice, it is necessary to assume in the subjects the role of developing different skills, such as writing, observation, inquiry, proposition of hypotheses, analysis, among other collective actions (COSTA and GALEGO, 2018).

In the context of continuing or initial training courses, which occur in the modality of online distance education, we highlight, according to the work of A33, the promotion of the digital inclusion of teachers who lack this, so that, in addition to providing the insertion in training spaces, constitutes a didactic tool. During the training course, the realization of experimental practices of Physics by teachers in the early years, from low-cost materials present in their homes, contributed to break with the idea that a Science/Physics laboratory is only one consisting of sophisticated equipment. With this digital technology has become allied in the socialization and expansion of knowledge, something still valid today. Thus, the computer as a technological tool, in addition to strengthening teaching knowledge, benefits students, since they will be involved with new proposals (OLIVEIRA and FREIRE, 2016).

Following the line of computers, but now focusing on software, in A17, it is observed that experimentation in online distance education courses can be an alternative, avoiding resorting to face-to-face classes to perform this type of activity. Through the Internet, software was used to conduct the experimental procedure “light radiation and light and dark bodies”, allowing the control server to monitor users who were out of university, both in the collection and sending of data. As it was exposed, there was the possibility of users interacting connected to the system. In Hoffmann (2017), we understand that the use of programs and software enhances the exploration of experiments, because through animation and simulation, a phenomenon of nature is idealized. Thus, programs and software are also constituted, as an experiment that uses scientific knowledge from technological development.

In some writings we noticed that the real experimental activities related to the use of computer simulation, laboratory, audiovisual production and virtual activity appear as a didactic-methodological strategy of mediation in physics teaching. Of these, in A29 it emerges that the emergence of virtual laboratories should be seen as complementary to physical laboratories, in the sense that one should not replace the other, but add as a resource available to the teaching of Physics and without prejudice to learning. With this, it is essential to consider the objectives and claims of the teacher about the development of his class, as well as the skills and competencies he would like to evoke in his students. In this sense, the use of scripts “cake recipe”, which make it impossible to reflect on the content or excessively open, that cognitively overload students or culminate in the arrival of a “right answer”, devoid of contextualization, should be avoided.

In favor of this, Tori (2010) emphasizes that the use of virtual resources can also be a support for face-to-face activities, real and virtual experimentation, for example. Face-to-face classes with communication via virtual learning environments or virtual resources, with the physical presence of a teacher, add potential for cooperation between the virtual and the face-to-face, mainly by incorporating collaborative practices that motivate and involve the subjects through digital communication technologies.

In this logic, the writing of A24, after bibliographic research investigated the integration of real and virtual experiments as a methodological strategy for the teaching of Geometric Optics. It is worth highlighting the scarcity of productions in this bias, mainly focusing on teaching the theme mentioned above, emerging only the separate use of these strategies. However, the authors reinforce that the articulation of these activities helps not only in the scientific development, but in the technological and cultural development of students.

Leiria and Mataruco (2015) infer that as methodological strategy experimental activities, real or virtual, require pedagogical and epistemological foundation, in the sense that they provide a relationship between the natural and artificial aspects that permeate a phenomenon, favoring the investigative spirit of the students. Following this perspective, in the writing of A25 the focus of the study is on the frequency and use of simulation applications about wave phenomena in a physics classroom of a technical high school, as well as the relevance in activities mediated by other resources. It was observed that the applications were allied to the use of mediational resources, such as experiments with manipulation of real artifacts. We emphasize that similar importance was attributed by the teacher, who used them in an integrated way and with the same frequency in the classes.

One of the studies present in A30 is the understanding of how supervising and licensing teachers of a group of the Institutional Program of Teaching Initiation Scholarships - PIBID physics examine the possibilities of using experimentation and simulation in the teaching of the area, from the experience in the program. Before an Interactive Exhibition, the conception of the participants was not favorable to the use of the simulation, because they believed they ran the risk of replacing the real experimentation with a resource that could present limitations in the way of representing reality, something that later changed, that is, in general the participants understood that both are distinct ways of seeing a phenomenon, but subject to complementation. In addition, they constitute a mediational resource in the rescue of the student as an active subject of their learning.

In the Research of A31, it is necessary to identify whether five public schools in the region of Rondônia use virtual and real experiments that favor a significant learning based on the context of the students. For this, a survey was conducted with teachers, students and administrative education. On this occasion, it was evidenced that most teachers do not integrate and resist the use of virtual pedagogical resources. The schools, although deficient, present laboratory rooms of Science and Informatics, but are not linked to the study and research in the area of Physics, demonstrating that the contents worked follow a more traditional aspect. This resistance and insecurity presented by teachers regarding the use of virtual technologies and resources, results from the lack of opportunity and training that allow them to reflect and problematize in a detailed approach on situations of use, highlighting the benefits for teaching and learning (OLIVEIRA; MOURA; SOUZA, 2015).

A20's research exposes that experimentation appears tied to the production of instructional experimental videos in the context of the training of physics teachers, that is, students who participated in a scientific initiation project entrusted with the production of audiovisual materials, aiming to make available to new teachers who did not have experience with laboratories. With these activities, we noticed the intellectual growth of the group, which had the instruction of the guiding teacher about lighting, framing, among other aspects for such a production. With the discussion carried out in the research, it is explicit that the audiovisual began to be seen as a tool that with sound and images captivates the student's attention and assists in the teaching of Physics, increasing the possibilities of transporting it to situations of their daily life.

Pereira *et al.* (2011) mention that experimental demonstrations in audiovisual format are different in relation to the traditional approach in the laboratory, since in this case, students can in a recursive-reflective and non-linear manner, research, raise concepts, create the experimental situation, test, modify and verify it whenever necessary. And even denoting the student's responsibility during the production, they should also count on the teacher guiding the process.

In A14, the focus is on the effects of the AVA on the motivation and learning of students of a public high school regarding the physics discipline. In addition to the teacher using experiments, simulations, texts and videos as a methodological strategy, he also used the forum tool in order to enable interaction between students. These classes took place in the space of the school's computer lab, fortnightly, were interspersed with face-to-face classes. It was concluded that most students considered that virtual activities contributed to the understanding of the phenomena studied, as opposed to a minority, who had difficulties and found the dynamics of online classes tiring, hindering their performance. In this work it is evident the importance that the choice of learning tools and objects is made thinking about the scope of learning through the interaction between students and teacher, and students with the objects and tools made available in the environment.

Heckler, Fazio and Ruas (2020) highlight that the emergence of web 2.0 permeated us by platforms, virtual learning environments, interfaces / tools such as simulators, applications, videos, animations, among other resources, showing us another side of the science laboratory. In this laboratory, the actions in experimentation change, recounting more with the collaboration between the subjects, geographically distant or not, who become co-authors in the process. When intended for the online context, experimentation can also assume a collaborative and dialogical approach, and through web 2.0 interfaces/ tools, constitute a scenario that values collaborative mediation in the search to improve understandings around the themes of study (HECKLER, 2014).

From the analysis performed, we verified the numerous possibilities of integration of virtual and real resources that permeate the didactic strategies and the formative spaces of teaching with regard to experimentation, not attributing greater importance to one or the other. Thus, whether in the online, face-to-face or hybrid modality, the combination and cooperation of such resources and activities provides opportunities to add what best constitutes them, so that they converge in the bias of interaction, collaboration, dialogue and the exchange of knowledge, they will be fulfilling their role in teaching and learning.

3.2 Didactic Tools: The Potentialities and Limits that Cross the Use of the Virtual and Face-to-Face Experiment in Physics Teaching

In this category, in addition to the didactic spaces and strategies, a discussion was made about the wide variety of tools, didactic artifacts and methodologies, which are addressed in different theoretical and practical contexts that will be discussed below. In addition to the identification and understanding of these contexts, we seek the potentialities and limitations, based on the experiences reported in the studies, which involve the use of different forms of experimentation.

The difficulty of students and high rates of disapproval (A17, A20), the use of methodologies aimed at content exposure (A6, A17, A20), the memorization of formulas (A20), the lack of relationship of content with daily life (A4) and the lack of motivation and interest in relation to physics (A27) are some evidences pointed out by the authors that motivate them to reflect on the theoretical-practical aspects of physics teaching. Another factor pointed out in the studies is the high degree of abstraction of physics contents (A5, A19, A20, A23, A25, A37 and A38), thus, real experimentation, remote experimentation, virtual laboratories, use of simulations and simulators as didactic tools emerge to potentiate and rethink teaching and learning methodologies in Physics.

It is interesting to affirm that the concern with physics teaching, its methodologies and teaching and learning relationships are recurrent themes in education research in the national and international scenario. In the latter, recent studies point to the lack of well-equipped laboratories (COFFIE; FREMPONG; APPIAH, 2020; Souza, SOUZA, AXE; SANTOS, 2020), the lack of interest of students and motivation of teachers (SOUZA; AXE; SANTOS, 2020) as factors that continue to challenge teaching and learning relationships in Physics. In Brazil, in addition to the reasons pointed out by the analyzed studies, recent studies by Lima (2019) and Cardoso *et al.* (2020), discuss, in addition to infrastructure issues, the lack of incentive to train the teaching professional to elaborate and carry out practical activities and, for this reason, have difficulties in developing lesson plans that include these activities.

However, assuming the importance of conducting experiments in the teaching of Physics, the authors point out reasons why there is still absence of these activities in the basic network and higher education, they are: lack of infrastructure (A4, A14, A34), laboratory costs (A17, A39), duration of some experiments (A34), lack of materials (A14, A34), insufficient teacher workload (A4) and lack of laboratory technicians (A14). For these reasons, A12 approaches as an alternative the remote experiment in laboratories that transcend the physical space of educational institutions, in their varieties and contexts.

In this sense, the use of didactic tools in the online context emerges as an important resource to address these problems in relation to physics teaching. Some studies propose the use of experimentation through virtual laboratories while others propose the use of remote laboratories. Remote laboratories can be remotely controlled by the student, provided that the artifact offers the student an interface that allows the experiment to be controlled remotely, without the student's face-to-face need in the laboratory (AMARAL *et al.*, 2011). We exemplify the use of remote laboratories by A40 when proposing LabNet, which is a remote access laboratory that allows the realization of experiments via the Internet. The proposal of remote experimentation over the Internet is also made by A7 with the use of Arduino and interface construction assisted on a WebServer. Both point out as a potentiality the universalization of the laboratory, with few resources, without the need to build various teaching materials. Also according to Amaral *et al.* (2011), differently, students in virtual laboratories interact with models, representations of the real laboratory environment made possible by computational representations of reality. Some examples of these simulations will be presented in the following paragraphs.

Despite the unanimous conviction that the use of technologies for the teaching of physics and the performance of experimental activities are important resources to improve teaching and learning relationships, some authors point out weaknesses. A13, for example, expresses that the real laboratories have a wider range of equipment and that the virtual experiment is solitary, considering that the experimentation would take place between the user and the computer. In addition to the aspects related to the handling of equipment, A39 states that there needs to be dosage in the use of simulator software, also, because it is a system where there is total control of variables, avoiding damage and imperfections and generating insecurity and indetermination in relation to real practical situations. Moreover, it points out that the application of virtual tools replacing real experiments portrays only a generic situation of the real situations. Therefore, the student would have a false idea of content domain.

Other weaknesses are pointed out by A28, in which he argues about the impossibility of manual interaction between users and the experiment, stating that this lack can limit the understanding of the observed phenomenon and, according to A38, would have difficulty transferring knowledge to other similar situations. A5 and A14 find that the students' difficulties are related not only in relation to the artifacts themselves, but also in relation to commands, description of activities and understanding of experimental activity guides and communication of the observed. Despite these weaknesses, many studies defend the use of simulation as a way to represent phenomena that are not seen in real trials.

The teaching of Modern Physics (A37 and A23) and astronomical knowledge (A37) are topics discussed by their degree of abstraction. In A37, the idea is that students can understand quantum objects and

concepts associated with wave-particle duality, using the simulator with their aforementioned script. A23 proposes the development of a software capable of reproducing an experiment involving Stefan-Boltzmann's Law for black body radiation, commonly performed in a laboratory of Modern Physics. In these cases, the computer becomes the adjunct in the teaching and learning process while the student guarantees its role.

The context of distance learning is presented by other studies, which consider that the use of online simulators can meet the need for practical experiments in distance learning courses. A38 suggests the use of simulators in DE and, in its work, exemplifies the energy content considering that the simulator favored students to understand aspects that are not identified in the actual experiment, such as the principle of energy conservation.

With the idea of complementing the learning of a concept, A17 proposes two learning situations, one real and one virtual. It is noticed that some aspects become observable when represented in the virtual, while in the real students could only visualize the effects, which are a consequence of the observed processes. Therefore, it is considered that the integrated use of simulations and real experiments can overcome some weaknesses. As A16 points out, this integration should be part of a broader planning, with the use of learning modules that use software, such as Modellus and simulators such as PhET.

Other weaknesses in relation to the exclusive use of simulations can be addressed, according to A39, with the realization of real experiments initially, so the simulators would have the role of reinforcing the understandings about the phenomenon observed in the real experiment. PhET simulators are also pointed out by A3, A5 and A6 as of great potential when applied to physics didactic sequences and investigative activities that combine the simulators with real experiments.

Some positive points of integrated use are pointed out by A5, in which it states that combining virtual and real experiments allows the obtaining of more detailed and accurate data, which would only be possible with the use of very sophisticated devices. However, in addition to the advantages related to instrumental aspects, A12 created a proposal for the discussion of projectile movement, which students could interact with each other, with computer simulation and with real experience and, in this context, points out the importance of the teacher's role in mediating the integrated activity.

The use of hypermedia environments is advocated by A37 and A38, that is, environments that enable agile research resources, approach themes more comprehensively and increase the conditions for active participation, since students interact with the content through simulations, games, videos, images, texts and other resources. A33 and A39 state that the role of the teacher is to allow students to be able to become aware of the information they interact with, this wealth of information and possibilities ensures greater autonomy of the student during the process.

In a recent study, Ruas *et al.* (2020), point out that online training spaces are a means to enable the collaborative and articulated work of the subjects. Thus, it is necessary to develop proposals that enable the interpretation and representation of phenomena in view of the construction of explanatory phenomena. Recognizing the importance of experimentation as a way to problematize everyday phenomena, A4 suggests the use of ICT and reiterates the importance of the teacher as a mediator in the learning process, considering that these activities favor the interaction between students and the teacher. Heckler, Fazio and Ruas (2020) also point to interaction as an important factor in the development of experimental investigative projects of DE, where they encourage the promotion of experimental investigative projects allied to technological resources that promote interactive environments that incite co-creation and co-authorship. In this context, other works also transcend the barriers of experimentation and turn their gaze to the methodologies around them.

Defending the use of information and communication technologies - ICT, A33 believes that digital didactic material can provide interactivity beyond the informational character only. To do this, you need an interface that provides interactivity and co-authorship. Thus, the use of technological tools to perform experimental activities should be encouraged by following some clues, as fostered by the above emergencies, among them, it is necessary to select tools that have friendly interface and easy interaction, that are contextual language accessible and appropriate to the reality of students.

In addition to the tool, it is necessary that the teacher is a mediator, think of methodological approaches that incite students to interact with the tools and with each other, and that stimulate the investigative character and their autonomy. Thus, the chosen methodology may include other hypermedia resources to complement the use of simulation and, in the arrangement of structure for carrying out practical experiments, these may be associated with the use of simulations.

4. Final Considerations

Based on the analyses performed in this study, which aimed to understand what is shown about experimentation in physics in the online context, we mean that by permeate and constitute formative spaces that see by digital inclusion, reflection and problematization of didactic-methodological strategies online, the teacher will have more opportunities to aggregate online experimentation in his pedagogical practice. Thus, it is a way to reduce the resistance and insecurity that sometimes permeates the use of virtual technologies and resources.

We found that online experimentation through different resources, computer simulation, virtual laboratory, virtual activity and audiovisual production, constitutes potential for the development of more collaborative actions among the subjects. Its potentialities cross the use of experimentation and through hypermedia resources one can create investigative activities that use various digital objects that encourage the autonomy, co-creation and interactivity of students.

It is reiterated that the studies point to the development of new simulations with improved interfaces that may be increasingly connected with the different realities. By incorporating it into their pedagogical practice, the teacher will be guided by the motivation of the subjects, involvement with each other and with resources, favoring their investigative spirit, thus having a fundamental role in the proposition of the activities, organization and orientation of the student's investigative process, whether in online or face-to-face environments.

Allied to this, we understand that the integration between virtual and real resources within the face-to-face, distance or hybrid modality constitutes a way for classes to become more interactive, denoting each one importance and complementarity. The teacher will be responsible for using these didactic-methodological strategies in the creation of dynamics and activities that involve discussions among students, in order to expand collaborative actions in the classroom.

5. References

- AGUIAR, M. S.; CASTRO, R. M. de. Atividades experimentais e novas tecnologias nas disciplinas de Física no Ensino Médio. **Anais do XVII Simpósio Nacional de Ensino de Física**. São Luís – MA. 2007. Available at: <https://sec.sbfisica.org.br/eventos/snef/xvii/atas/resumos/T0525-1.pdf>. Access in: 15 jul. 2020.
- AGUIAR JÚNIOR, O. G.; VILLANI, C. E. P. Experimentos e simulações como recursos mediacionais no ensino de Física: reflexões no curso de experiência de formação docente no PIBID/UFMG. **Anais do XIV Encontro de Pesquisa em Ensino de Física**. São Sebastião – SP. 2012. Available at: <https://sec.sbfisica.org.br/eventos/epf/xiv/sys/resumos/T0314-1.pdf>. Access in: 15 jul.2020.

- AGUIAR, M. D. *et al.* Teacher malaise in physics teaching: perspectives and challenges. **Research, Society and Development**, v. 9, n. 6, p. e106963265, 2020.
- ALVES, N. F.; NEIDE, I. G. A Integração de atividades experimentais e computacionais para o ensino de Física: uma possível estratégia para o ensino de Óptica Geométrica. **Anais do XVII Encontro de Pesquisa em Ensino de Física**. Campos do Jordão - SP. 2018. Available at: <https://sec.sbfisica.org.br/eventos/epef/xvii/programa/trabalhos.asp?sesId=39>. Access in: 15 jul. 2020.
- AMARAL, É. *et al.* Laboratório virtual de aprendizagem: uma proposta taxonômica. **RENOTE-Revista Novas Tecnologias na Educação**, v.9, n.2, 2011.
- BORGES, M. C. Formação inicial e continuada no PIBID - Experiências entre atores da Educação Básica e Superior. **Anais do XVII ENDIPE**. Fortaleza – CE. 2014.
- CAETANO, T. C.; SILVA, A. P. da; MOREIRA, C. C. Desenvolvimento de experimentos de acesso remoto para o ensino de Física: uma investigação sobre as potencialidades do experimento anel de Thomson. **XV Encontro de Pesquisa em Ensino de Física**. São Sebastião – SP. 2014. Available at: <http://www.sbfisica.org.br/~epef/xv/>. Access in: 15 jul. 2020.
- CARDOSO G. F.; SILVA, A. C.; VILARDI, L. Os Desafios na Utilização do Laboratório de Ensino de Ciências pelos professores de Ciências da Natureza. **Revista Insignare Scientia** - RIS, v. 3, n. 2, p. 274-291, 24 ago. 2020.
- CARVALHO, D. L. de; DUARTE, J. L. M.; PACCA, J. L. de A. Um curso a distância sobre eletromagnetismo: o planejamento e o processo de aprendizagem. **IX Encontro de Pesquisa em Ensino de Física**. Jaboticabaus - MG. 2004. Available at: <https://sec.sbfisica.org.br/eventos/epef/ix/>. Access in: 15 jul. 2020.
- COFFIE, I. S.; FREMPONG, B. B.; APPIAH, E. Teaching and Learning Physics in Senior High Schools in Ghana: The Challenges and the Way Forward. *Advances in Research*, v. 21, n.3, p. 35-42, 2020.
- COSTA, S. C.; GALEGO, L. G. C. Experimentação e formação inicial docente em Ciências no PIBID: relato de experiência. **Revista Iniciação & Formação Docente**, vol.5, n.1, p.1-14, 2018.
- DUARTE, M.; JAMMAL, N.; JUNIOR, E. da C. Atividades experimentais de bancada e simulações computacionais: percepções dos alunos sobre realidade. **XV Encontro de Pesquisa em Ensino de Física**. São Sebastião – SP. 2014. Available at: <http://www.sbfisica.org.br/~epef/xv/>. Access in: 15 jul. 2020.
- DUTRA, L. de. M; BARROSO, M. F. O uso de experimentos como ferramenta de ensino e aprendizagem: estudo de um caso. **Anais do XX Simpósio Nacional de Ensino de Física**. São Paulo – SP. 2013. Available at: <https://sec.sbfisica.org.br/eventos/snef/xx/sys/resumos/T0552-1.pdf>. Access in: 15 jul. 2020.
- EVANGELHO, B. V do; SANTOS, R. C. M. **Anais do XXII Simpósio Nacional de Ensino de Física**. São Carlos – SP. 2017. Available at: <https://sec.sbfisica.org.br/eventos/snef/xxii/sys/resumos/T0594-1.pdf>. Access in: 15 ago. 2020.
- GAMA, C. F.; PAZÊTO, F.; COUVEIA, R. C. Vídeo instrucional – montagem de experimentos. **Anais do XVI Simpósio Nacional de Ensino de Física**. Rio de Janeiro – RJ. 2005. Available at: <https://sec.sbfisica.org.br/eventos/snef/xvi/cd/resumos/T0641-1.pdf>. Access in: 23 ago. 2020.
- GOMES, *et al.* Desenvolvimento de um app android para auxiliar a confecção de experimentos alternativos para o ensino de Física. **Anais do XXII Simpósio Nacional de Ensino de Física**. São Carlos – SP. 2017. Available at: <https://sec.sbfisica.org.br/eventos/snef/xxii/sys/resumos/T1946-1.pdf>. Access in 15 ago. 2020.
- GOUVEIA, R. C.; GAMA, C. F.; PAZÊTO, F. Vídeo Instrucional - Montagem de Experimentos. **Anais do XVI Simpósio Nacional de Ensino de Física**. Rio de Janeiro-RJ. 2005. Available at: <https://sec.sbfisica.org.br/eventos/snef/xvi/>. Access in: 2. dez. 2019.

- HECKLER, V.; *et al.* A experimentação em Ciências online envolve sujeitos em pesquisa-formação ao operar objeto aperfeiçoável imersos na linguagem. **Atas do VIII ENPEC**. Campinas – SP. 2011. Available at: http://abrapecnet.org.br/atas_enpec/viii/enpec/resumos/R0862-1.pdf. Access in 13 jul. 2020.
- HECKLER, V. Experimentação em Ciências na EaD: indagação online com os professores em AVA. 2014. 242 p. **Tese (Doutorado em Educação em Ciências)**. Programa de Pós-Graduação em Educação em Ciências: Química da Vida e Saúde, Universidade Federal do Rio Grande, Rio Grande, 2014.
- HECKLER, V.; FAZIO, A. A.; RUAS, F. P. Investigação com Atividades Práticas Experimentais na formação com professores geograficamente distantes. **Journal of Research and Knowledge Spreading**, v. 1, n.1, p.1-12, 2020.
- HEIDEMANN, L. A.; ARAUJO, I. S. ; VEIT, E. A. Experimentos empíricos versus simulações computacionais: uma controvérsia no ensino de Física. **Anais do XIV Encontro de Pesquisa em Ensino de Física**. Maresias-SP. 2012. Available at: <http://www.sbfisica.org.br/~epef/xiv/>. Acesso em: 15 jul. 2020.
- HOFFMANN, J. L. O panorama de uso da experimentação no ensino da Física em municípios da região oeste do Paraná: uma análise dos desafios e das possibilidades. 2017. 198 p. **Dissertação (Mestrado em Educação)**. Programa de Pós-Graduação Stricto Sensu em Educação, Universidade Estadual do Oeste do Paraná, Cascavel, 2017.
- IWAMOTO, H. K. S.; CAETANO, T. C.; SILVA, A. P. da; Desenvolvimento de um experimento remoto para o ensino de física: ondas estacionárias. **Anais do XXI Simpósio Nacional de Ensino de Física**. Uberlândia – MG. 2015. Available at: <https://sec.sbfisica.org.br/eventos/snef/xxi/sys/resumos/T1050-1.pdf>. Access in: 5 ago. 2020.
- KOEHLER, L. F.; MAZER, H.; BRINATTI, A. M. Lei de Stefan-Boltzmann: uma experiência virtual. Anais do XV Simpósio Nacional de Ensino de Física. Curitiba - PR. 2003. Available at: <https://sec.sbfisica.org.br/eventos/snef/xv/>. Available at: 22 jul. 2020.
- LEAL, A. C. da S.; *et al.* Utilização de simulação computacional, experimento e intermediação do professor no ensino de movimento de projéteis para o Ensino Médio. **Anais do XXI Simpósio Nacional de Ensino de Física**. Uberlândia – MG. 2015. Available at: <https://sec.sbfisica.org.br/eventos/snef/xxi/sys/resumos/T0629-1.pdf>. Access in: 5 ago. 2020.
- LEIRIA, T. F.; MATARUCO, S. M. C. O Papel das Atividades Experimentais no Processo Ensino-Aprendizagem de Física. **Anais do Educere - XII Congresso Nacional de Educação**. Curitiba - PR. 2015. Available at: <https://educere.pucpr.br/pt/>. Access in: 4 mai. 2020.
- LIMA, E. G. Metodologia alternativa para o ensino de Física: experimento de baixo custo em Mecânica. 2019. 50 f. **Trabalho de Conclusão de Curso (Licenciatura em Física)** - Centro de Ciências, Universidade Federal do Ceará, Fortaleza, 2019
- LOPES, R. P.; *et al.* Experimentação real e virtual de circuitos elétricos simples como ferramenta mediadora no processo de aprendizagem de Física. **Anais do XVIII Simpósio Nacional de Ensino de Física**. Vitória – Espírito Santo. 2009. Available at: <https://sec.sbfisica.org.br/eventos/snef/xviii/>. Access in: 12 jul. 2020.
- MENDES, M. A.; FIALHO, F. A. P. Experimentação tecnológica prática a distância. **Anais do 12º Congresso Internacional de Educação a Distância**. Florianópolis – SC. 2005. Available at: <http://www.abed.org.br/congresso2005/por/home.htm>. Access in: 14 mai. 2020.
- MONTEIRO, J. C. B. *et al.* Os ambientes virtuais de aprendizagem (AVA) como fator de motivação no ensino de Física. **Anais do XX Simpósio Nacional de Ensino de Física – SNEF**. São Paulo - SP. 2013. Available at: <https://sec.sbfisica.org.br/eventos/snef/xx/sys/resumos/T0550-1.pdf>. Access in: 15 jul. 2020.

- MONTEIRO, M. A. A. *et al.* Experimento controlado remotamente para o estudo da cinemática. **Anais do XX Simpósio Nacional de Ensino de Física**. São Paulo – SP. 2013. Available at: <https://sec.sbfisica.org.br/eventos/snef/xx/sys/resumos/T1042-1.pdf>. Access in: 15 jul. 2020.
- MOREIRA, R. M.; MANTILLA, S. P. S. Atividade experimental e simuladores didáticos on-line: impacto na aprendizagem de Física. **Anais do 21º Congresso Internacional de Educação a Distância**. Bento Gonçalves – RS. 2015. Available at: <http://www.abed.org.br/hotsite/21-ciaed/pt/anais/>. Access in: 14 mai. 2020.
- MORO, F. T.; NEIDE, I. G.; VETTORI, M. Atividades experimentais e simulações computacionais: alicerces dos processos de ensino e de aprendizagem da Física no Ensino Médio. **Anais do XXI Simpósio Nacional de Ensino de Física**. Uberlândia – MG. 2015. Available at: <https://sec.sbfisica.org.br/eventos/snef/xxi/sys/resumos/T1059-1.pdf>. Access in 5 ago. 2020.
- NEIDE, I. G.; GAMA JÚNIOR, R. C. Um diagnóstico das publicações sobre a integração das atividades experimentais e computacionais no ensino de Física. **Anais do XVII Encontro de Pesquisa em Ensino de Física**. Campos do Jordão – SP. 2018. Available at: <http://www.sbfisica.org.br/~epef/xvii/index.php/pt/index.html>. Access in: 15 jul. 2020.
- NEVES, J. A.; *et al.* Simuladores como atividades práticas complementares ao laboratório real. **Anais do XX Simpósio Nacional de Ensino de Física**. São Paulo – SP. 2013. Available at: <https://sec.sbfisica.org.br/eventos/snef/xx/sys/resumos/T1043-1.pdf>. Access in: 15 jul. 2020.
- NÓBREGA-THIERREN, S.M. ; THIERREN, J. Trabalhos Científicos e o Estado da Questão: reflexões teórico-metodológicas. **Estudos em Avaliação Educacional**, v. 15, n. 30, jul-dez./2004
- OLIVEIRA, C. de; MOURA, S.P.; SOUZA, E.R. de. TIC's na Educação: a utilização das tecnologias da informação e comunicação na aprendizagem do aluno. **Revista Pedagogia em Ação**, v.7, n.1, 2015.
- OLIVEIRA, H. S.; FREIRE, M. L. F. . O computador e o ensino de Física: simulação e modelagem computacional. **Revista Compartilhando Saberes**, v. 1, p. 40, 2014.
- PEREIRA, M. V. *et al.* Demonstrações experimentais de Física em formato audiovisual produzidas por alunos do Ensino Médio. **Caderno Brasileiro de Ensino de Física**, v. 28, p. 676-692, 2011.
- PESSANHA, M. C. R; COZENDEY, S. G.; SOUZA, M. O. Interação entre luz e matéria: um experimento com acesso a distância através da Internet. **Anais do XVIII Simpósio Nacional de Ensino de Física**. Vitória – ES. 2009. Available at: <https://sec.sbfisica.org.br/eventos/snef/xviii/programa/lista_trabalho.asp?sesId=23>. Access in: 15 jul.2020.
- PONTONE JUNIOR, R.; PAULA, H. F. Caracterização geral do uso de simulações e laboratórios virtuais em uma sala de aula de Física. **Anais do XVII Encontro de Pesquisa em Ensino de Física**. Campos do Jordão-SP. 2018. Available at: <<https://sec.sbfisica.org.br/eventos/epf/xvii/programa/trabalhos.asp?sesId=39>>. Acesso em: 15 jul.2020.
- RUAS, F. P. *et al.* Formação Online de professores de ciências: a construção de modelos explicativos com vistas a compreensão de fenômenos. In: KRAUSE, J.C et al.(org.). **Formação docente e educação científica**. Cruz Alta: Ilustração, 2020. p.229-240.
- SALES, G. L.; LEITE, E. A. M; VASCONCELOS, G. H. L. TDIC como suporte à aprendizagem de física no Ensino Médio. **Anais do XXI Simpósio Nacional de Ensino de Física**. Uberlândia – MG. 2015. Available at: <https://sec.sbfisica.org.br/eventos/snef/xxi/sys/resumos/T0006-1.pdf>. Access in: 2 ago. 2020.
- SANTOS, J. C. dos. *et al.* Conciliando experimento e simulação computacional no ensino de queda livre. **Anais do XXII Simpósio Nacional de Ensino de Física**. São Carlos – SP. 2017. Available at: <https://sec.sbfisica.org.br/eventos/snef/xxii/sys/resumos/T0604-1.pdf>. Access in 15 ago. 2020.

- SCHUCK, A. F.; SERRANO, A. Um exemplo do uso de experimentos virtuais objetivando a introdução de conceitos de mecânica quântica na disciplina de estrutura da matéria. **IX Encontro de Pesquisa em Ensino de Física**. Jaboticabaus - MG. 2004. Available at: <https://sec.sbfisica.org.br/eventos/epenf/ix/>. Access in: 15 jul. 2020.
- SENA, M.; SILVA, R.; MARTINS, A. Oficina de experimentos virtuais de física para o Ensino Médio. **Anais do XVI Encontro de Pesquisa em Ensino de Física**. Natal – RN. 2016. Available at: <http://sbfisica.org.br/~fisica2016/>. Acesso em: 11 set. 2020.
- SILVA, N. C. da. Laboratório virtual de Física Moderna: simulações para seis arranjos experimentais. **Anais do XX Simpósio Nacional de Ensino de Física**. São Paulo – SP. 2013. Available at: <https://sec.sbfisica.org.br/eventos/snef/xx/sys/resumos/T0471-1.pdf>. Access in: 15 jul. 2020.
- SILVA, T. da. Um material didático hiperfídia para o ensino de fenômenos astronômicos. **Anais do XVII Simpósio Nacional de Ensino de Física**. São Luís – MA. 2007. Available at: <https://sec.sbfisica.org.br/eventos/snef/xvii/atas/resumos/T0503-1.pdf>. Access in: 15 jul. 2020.
- SILVA, M. J. V. T. da; ANGOTTI, J. A. P.; MION, R. A. Revitalizar laboratórios para ensinar física: possibilidades dos softwares de autoria em atividades teórico-experimentais. **Anais do XI Encontro de Pesquisa em Ensino de Física**. Curitiba – PR. 2008. Available at: <https://sec.sbfisica.org.br/eventos/epenf/xi/resumo.shtml>. Access in: 11 set. 2020.
- SILVA, T. da; BARROSO, M. F. Fenômenos astronômicos e ensino a distância: produção e avaliação de materiais didáticos. **Anais do XI Encontro de Pesquisa em Ensino de Física**. Curitiba – PR. 2008. Available at: <https://sec.sbfisica.org.br/eventos/epenf/xi/resumo.shtml>. Access in: 11 set. 2020.
- SILVA, J. C. *et al.* Usos de simulações em aulas de física: o fazer e o refletir de equipe do PIBID Física UFMG. **Anais do XXI Simpósio Nacional de Ensino de Física**. Uberlândia – MG. 2015. Available at: <https://sec.sbfisica.org.br/eventos/snef/xxi/sys/resumos/T0569-2.pdf>. Access in: 5 ago. 2020.
- SILVA, C.F. da. *et al.* Atividade virtual de física em escolas de Rondônia. **Anais do XIV Encontro de Pesquisa em Ensino de Física**. Maresias - SP. 2012. Available at: <https://sec.sbfisica.org.br/eventos/epenf/xiv/sys/resumos/T0137-1.pdf> >. Access in: 15 jul.2020.
- SIM, A. A. do; MONTEIRO, M. A. A. Experimento remoto como ferramenta de aprendizagem: um estudo comparativo. **Anais do XXII Simpósio Nacional de Ensino de Física**. São Carlos – SP. 2017. Available at: <https://sec.sbfisica.org.br/eventos/snef/xxii/sys/resumos/T0426-1.pdf>. Access in 15 ago. 2020.
- SOUZA, G. L. de *et al.* Experimentação Remota no Ensino de Física. **Anais do XV Simpósio Nacional de Ensino de Física**. Curitiba - PR. 2003. Available at: <https://sec.sbfisica.org.br/eventos/snef/xv/>. Acesso em: 22 jul. 2020.
- SOUZA, C. P. de; COSTA FILHO, J. T. Laboratório a distância - um novo recurso na educação a distância. **Anais do 8º Congresso Internacional de Educação a Distância**. Brasília - DF. 2001. Available at: <http://www.abed.org.br/congresso2001/>. Access in: 14 mai. 2020.
- STEIN-BARANA, A. C. de M.; LOPES, D. P. M. Temas de Física no ensino de Ciências: formação continuada a distância de professores do primeiro ciclo do Ensino Fundamental associada à inclusão digital. **Anais do XI Encontro de Pesquisa em Ensino de Física**. Curitiba – PR. 2008. Available at: <https://sec.sbfisica.org.br/eventos/epenf/xi/resumo.shtml>. Access in: 11 set. 2020.
- TORI, R. **Educação sem distância**: As Tecnologias Interativas na Redução de Distâncias em Ensino e Aprendizagem. 1. ed. São Paulo: Editora Senac São Paulo, v. 1. 256p. 2010.
- XAVIER, A. P.; VERTCHENKO, L.; AMANTES, A. Atividade prática associada à simulação computacional para o ensino de conceitos de hidrodinâmica. **Anais do XXI Simpósio Nacional de Ensino de Física**. Uberlândia – MG. 2015. Available at: <https://sec.sbfisica.org.br/eventos/snef/xxi/sys/resumos/T0954-1.pdf>. Access in: 2 ago. 2020.