

# Enunciative Texts Present in Physical Issues of Editions of a Brazilian National Exam as Possible Triggers of Socio-Scientific Discussions

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## Abstract

In this article we identify and analyze texts on physics questions in seven editions of a Brazilian national exam, with the purpose of bringing contributions to teaching planning and pedagogical actions with the perspective of supporting the creation of socio-scientific discussions (SSD), capable of inducing students in their citizenship development, in view of the difficulties of being worked in Sciences/Physics teaching environments appointed by the literature. A Brazilian state was chosen as a field, whose locus included six municipalities and 12 public institutions of basic education. Given that the results seem to distort the reality of the school context, the aforementioned difficulties were then theoretically and empirically disassembled, proving to be potentially minimized with the establishment of trails that enable the teacher to work on SSD identified in materials of easy and universal access, which contributes with advancement in the field of Science-Technology-Society education.

## Keywords

STS Education, Controversial Themes in the Classroom, Socio-Scientific Issues in National Exam, Socio-Scientific Discussions and Teaching Plan

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## 1. Introduction

The study is part of the Brazilian educational context of the National High School Examination (NHSE) (Fernandes-Sobrinho, 2017) in which we seek to

highlight the importance of scientific and technological education, with the perception and understanding of nature, according to the social world. This education presupposes teaching-learning activities, admittedly important, weighted on (and from) discussions of socio-scientific issues (SSI) capable of inducing the citizenship development (Fernandes-Sobrinho, Ramos, Souza, & Santos, 2017). Although the literature strongly recommends them, it points out difficulties to work with them (Martínez Pérez & Carvalho, 2012).

As important forms of analysis, currently present in qualitative research, we highlight the documentary and the content in the development of a broader work—doctoral thesis of the author—that identified, selected and analyzed new sources of textual genres to support planning and pedagogical actions inserted in the perspective of STS education, in particular, the discussions of socio-scientific issues (SSI) (Fernandes-Sobrinho, 2016).

In this article we reinforce the idea that the insertion of STS education: 1) in the context of the Natural Sciences classroom (NS); and 2) in questions related to these NS, makes it possible to overcome naive conceptions about scientific neutrality. To a large extent, we believe that this insertion may imply an increase in the student's interest in learning scientific concepts and, as a consequence, in assisting it in critical and reflexive development, in the face of social and personal aspects.

We also emphasize the considerable importance of forming critical citizens, and which is widely defended in the official Brazilian educational curriculum Strieder, Silva, Fernandes-Sobrinho and Santos (2016), including those that guide the National Program of School Books (NPSB) and the National Examination of Secondary Education (NESE), in addition to what researches in science education, not only in Brazil, point out about the importance of taking socio-scientific issues to the classrooms (SSI) and (or) controversial from a scientific point of view.

## 2. Development

In this article, we develop a study in the theoretical and empirical scope, satisfying the concrete conditions of real contexts. The general objective was to verify and identify, in questions of physics, in the valid editions of the NESE from 2009 to 2015, the potentialities to work on socio-scientific discussions (DSC) in science classrooms. In this sense, we have expanded the number of sources and textual genres, of this nature, as feasible alternatives (and of easy and free access) to the teacher and the student (Fernandes-Sobrinho, 2016; Fernandes-Sobrinho, Ramos, & Santos, 2016; Sobrinho, Ramos, Fernandes, Castro, & Silva, 2017), as a perspective of contributing towards a more effective implementation of SSI discussions, in Physics teaching, as opposed to the difficulty of this implementation (Martínez-Pérez, 2012; Martínez Pérez & Carvalho, 2012).

We structure the analysis developed for each research object (NESE) and its relation with the corresponding questions, in order to establish necessary and

sufficient connections to the attainment of our purposes.

Considering what the literature points out regarding the difficulties for the teacher to work on SSQ discussions in science classes, we take the following pertinent question: “which indicators in NHSE questions and in the speech of physics teachers, allow us to identify and systematize possible articulations of SST discussions in the context of the classroom?”, which emerged on the basis of a data/information survey.

In the present study, our concern was not limited to the descriptive record of the facts/elements, although there are descriptions throughout its construction. From the empirical-theoretical interweaving, we tried to advance to a level of understanding and explanation, relating theory-data as founders in our reflections.

We developed the methodological design of the research in the middle of an emerging dynamics, in the sense of being a process elaborated in the course of the study, notably marked by advances and setbacks, conceptualizations, definitions, adjustments and restructurings. All this, in a logic of progressive discovery; inductive logic (Strauss & Corbin, 2008). In this regard, methodological changes were introduced, in line with what they teach us Ketele and Roegiers (1999), stating that “the researcher must at all times combine creativity and rigor, continually adapting to the context and evolution of research”.

According to Lüdke and André (2012) “a documental analysis can be a valuable technique for approaching qualitative data and also complementing the information obtained by other collection techniques”.

Thus, we answer with a documental basis, the research question related to NHSE: what questions of physics in NHSE (2009-2015) [and in what way] can potentiate discussions, from SST, in the classroom environment?

In view of the extension of the NESE material analyzed, we adopted as a criterion of sample delimitation the disregard of the editions related to the second applications of the test, when found—those editions generally intended for persons deprived of liberty (PDL).

We would like to stress that in the present study we do not emphasize the documents directed and pertinent to NESE. On the other hand, we necessarily visit them, in addition to consulting works (articles, dissertations and thesis) related to them, only as an initial stage of the screening of documents of interest and relevance to the objectives of Science-Technology-Society (STS) education.

The main purpose of this procedure was to assist us in the identification of Physics questions with potential to work on discussions based on SSI. This also allowed us to construct scripts and preparation guides for the “semi-open questionnaire” and the “semi-structured interview” [cf. Present appendices in (Fernandes-Sobrinho, 2016)].

For the identification and analysis of NESE Physics questions, with the potential to work SSI, we chose to use elements of Content Analysis and Document Analysis (Bardin, 2011). This was due to the fact that we understood they were

sufficient and properly systematized, to assist us in the treatment and analysis of the documents raised.

The interview analysis procedure was done through the Content Analysis (CA) (Bardin, 2011). We started with the definition of the unit of analysis (register and context), the choice of the material that composed the corpus, followed by floating reading, transcription in the whole of the lines, identification of categories first and possible later to finally identify the occurrence of categories in the analyzed texts.

Among the criteria pointed out by (Bardin, 2011), in order to perform the categorization (semantic, syntactic, lexical and expressive), we opted for the semantic most of the time, since our intention was to identify themes (explicit or implicit) in the analyzed questions.

Along with the teachers of the selected schools, we conducted an interpretative study that allowed us to understand how they appropriate, use and discuss concepts and materials (NESE questions) in their records. We thus appeal to the CA because it is an instrument of interpretive analysis that seeks the meaning (s) of a text (Bardin, 2011). Through this approach, we “deconstruct” and “construct” the transcription of each interview, in order to point out the relationship between the NESE and its practice, allowing us to make inferences such as: what did the subject do? Why did they do it that way?

The scope of this methodology is presented in four movements. In the first one, we make a brief historical contextualization (Fernandes-Sobrinho & Santos, 2014) of the objectives of CA, according to the one proposed by Bardin (2011). Then, in the second movement, we discuss the methodology used in order to establish the basis of the material analysis. In the next movement, we present the methodological criteria for coding and categorizing the corpus—a set of documents that were submitted to the analysis, which sometimes presupposes choices, selections and rules [of the study]. Finally, in the fourth and last movement, we discuss from hypotheses, possible interpretations and inferences.

In phase (a) of the pre-analysis, (Bardin, 2011), it describes the following subphases: i) Floating reading; ii) Choice of documents; The. Exhaustiveness rule; b. Rule of representativeness; c. Homogeneity rule; d. Relevance rule; iii) Formulation of hypotheses and objectives; iv) Reference of the indices and the elaboration of indicators; v) Preparation of the material.

In phase (b), the operation of the material is carried out “coding, discount or enumeration operations, according to previously formulated rules”. In phase (c) the treatment of the obtained results and their interpretations, the results obtained are related to the theoretical scope, also allowing the referral to the conclusions of the research and eventual future perspectives to the area.

### 3. Methodology

We aimed to identify sources, initially. From within them, we pre-select documents relevant to the research objectives, even that initially, without worrying to

analyze them adequately. At that time, the interest was basically to find materials/information contained in publications of scientific events related to the area of interest, in national and international periodicals, dissertation and thesis banks, as well as other documentary sources related to the descriptors: NESE and topics or aspects or socio-scientific issues, such as: laws, official Brazilian educational documents (PCN, DCNEM, NESE and others). Even at this stage, we “cover” the available materials (NESE tests).

Although during this phase there was no concern with the development of more accurate analyzes, the information were stored in files in the formats of their publications, usually in Portable Document Format (pdf), named according to terms that allowed us to identify, on other occasions and during the development of the thesis, source, theme, year of publication and authors. In addition, the files were placed in folders, whose names also served as a filter for revisiting those documents or information. Excel 2010 tables were built with the intention of also helping us organize the collection and storage of these preliminary data.

From the analysis of semi-structured transcribed interviews and NESE questions, tables were constructed with synthesis of the analyses that allowed us to establish categories, taking into account criteria proposed by [Bardin \(2011\)](#). Among the different analytical possibilities (thematic analysis, characteristics associated with the central theme, and sequential analysis), it was possible to identify, in the records units, records, some themes that helped us in these constructions.

In the process of constructing the categories of analysis [of NESE questions], once again the three categories proposed by [Wartha and Faljoni-Alário \(2005\)](#), adapted to Physics, were used, as already mentioned. In addition to the criteria used to identify the contextualisation of the questions, the set of 10 characteristics that identify the SSI proposed by [Ratcliffe and Grace \(2003: p. 22\)](#) were used as generative and categorical elements for SSI (explicit or implicit/latent), which are:

- 1) It is based in science, often in areas that are at the frontiers of scientific knowledge.
- 2) Involve the formation of opinions and the making of choices on a personal and social level.
- 3) They are frequently publicized by the media with emphasis on aspects based on the interests of the media.
- 4) Handle with incomplete information whether they are incomplete or conflicting scientific evidence and gaps in records.
- 5) Deal with local and global problems and their social and political structures.
- 6) Involve cost-benefit analysis in which risks interact with values.
- 7) May involve considerations on sustainable development.
- 8) Involve values and ethical reasoning.
- 9) May require some understanding of probability and risk.

10) They are often punctual during the transition of a life.

#### 4. Results and Discussion

We took into consideration words or terms that contextualized the physical<sup>1</sup> knowledge, in which it was borrowed one of the three aspects used by Wartha and Faljoni-Alário (2005), in the identification of “conception of the term contextualization” (page 44), in three categories adapted to Physics: 1) information of a physical nature, related to the scientific concept addressed or that are examples of scientific applications; 2) common sense ideas translated into scientific knowledge; 3) productive and/or environmental processes translated in physical terms.

From the exploratory study described, for the first stage of the screening of Physics questions, tables (one for each valid exam edition, in the analyzed period) were elaborated, as follows (Board 1).

After this phase to select the Physics questions, from the criteria to consider them with contextualization or not, we tried to raise the incidence frequency of each category (contextualization), constructing the following Table 1.

From the table above, it is inferred that the predominant category for the contextualization of Physics questions, throughout the editions of the exam, is “(1) Physics with scientific knowledge approached or applied”.

With this table in mind and with the purpose of making it easier to visualize these data, we constructed the corresponding chart of the figure below (Table 2).

Next, we present the table containing the number of physics questions, by exam edition and that satisfies the predominant characteristics in the item, of SSI, according to the proposal of Ratcliffe and Grace (2003).

The table above allows to state that the characteristic “(7) May involve considerations on sustainable development” predominates in the exam Physics questions, in the analyzed period, present in 23, of the 57 questions selected. It means that 40% of the questions, with SSI potential, belong to this characteristic. It was possible to notice that some characteristics, such as (3) and (10) were not contemplated, in the questions of the editions analyzed. Others were identified as poorly explored in the questions, as in the case of characteristics (5) and (6).

The two criteria used to categorize, select and analyze the Physics questions, proposed by Wartha and Faljoni-Alário (2005) and by Racliffe and Grace (2003), drew attention to the predominance of the variable with the contextualization profile (1) of the questions, and the quantity of the categorized variable with the potential for discussions based on SSI, by the characteristics of SSI, according to Racliffe and Grace (2003). In this sense, we tried to sketch the following chart, with the purpose of possible association between these categorized variables.

The graph of the Figure 1 above, of positive and negative association strength reveals that there is a clear negative association (kind of correlation, see footnote) between the variable categorized “questions with contextualizations of type (1)”

<sup>1</sup>Adapted from “chemical knowledge” from Wartha and Faljoni-Alário (2005).

**Board 1.** Selection of NESE/2010 Physics questions with potential for SSI.

NESE/2010—Bluebook					
Question	Answer	Knowledge object (s)	Subject (s)	Category	Socio Scientific Theme (SSI)
57	E	Electrical and Magnetic Phenomena	Electrodynamics/Capacitors	1	ACT and the criteria for a successful purchase decision.
70	C	Electrical and Magnetic Phenomena	Magnetism/Electromagnetic Induction	1	Science, technology and health.
85	B	Oscillations, waves, optics and radiation	Waves/Diffraction and Interference	1	Diffraction and the evolution of optical media.
90	E	The movement, the balance and the discovery of physical laws	Hydrostatic/Density	1	Hydrostatic against tampering.
59	E	Electrical and Magnetic Phenomena	Electrodynamics/Resistors and Resistance	1	NO
65	C	The movement, the balance and the discovery of physical laws	Hydrostatic	1	NO
81	E	Electrical and Magnetic Phenomena	Magnetism/Electromagnetic Induction	1	NO
89	A	Electrical and Magnetic Phenomena	Magnetism/Nanomagnetism	1	New materials and superbacteria.
58	E	Oscillations, waves, optics and radiation	Waves/Interferences	1	Piracy: ethical issues and values
64	D	The movement, the balance and the discovery of physical laws	Kinematic	1	Transit: education and security.
84	B	Electrical and Magnetic Phenomena	Electrodynamics/Power and circuits	2	Circuit breakers: against electrical surges.
67	E	Oscillations, waves, optics and radiation	Optics and Waves/Scattering	2	NO
54	C	Oscillations, waves, optics and radiation	Ótica/EspelhosEsféricos	2	Traffic and security
48	A	Energy, work and power	Energia	3	STSA/Alternative sources.
86	E	The movement, the balance and the discovery of physical laws	Dinâmica/Força e Energia Elástica	3	New materials and the accumulation of energy.

Source: Author's elaboration.

**Table 1.** Survey of the number of NESE physics questions, by contextualization category using the criteria proposed by Wartha and Faljoni-Alario (2005).

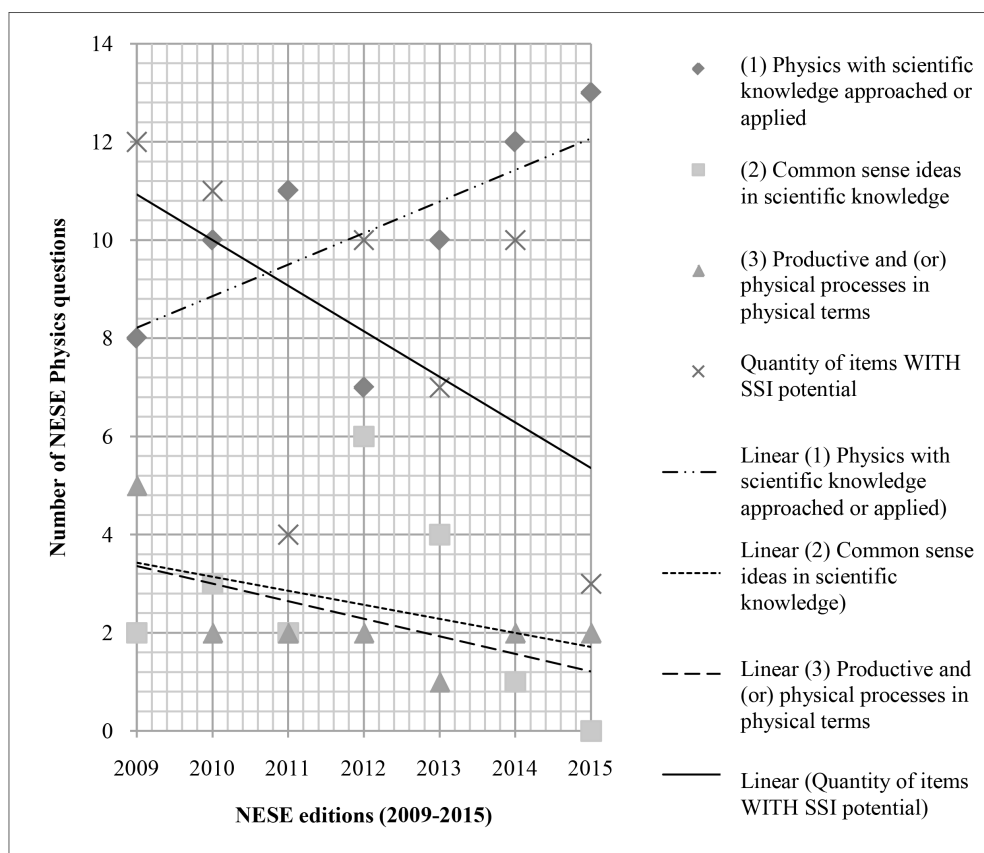
	1) Physics with approached or applied scientific knowledge	2) Common sense ideas in scientific knowledge	3) Productive and (or) physical processes in physical terms
2009	8	2	5
2010	10	3	2
2011	11	2	2
2012	7	6	2
2013	10	4	1
2014	12	1	2
2015	13	0	2

Source: Author's elaboration.

**Table 2.** Number of physics questions, by NESE edition, that satisfies SSI characteristics proposed by Ratcliffe and Grace (2003).

SSI characteristics proposed by Ratcliffe and Grace (2003)	2009	2010	2011	2012	2013	2014	2015	Total of questions by SSI characteristic
1) It is based in science, often in areas that are at the frontiers of scientific knowledge	1	2				1		4
2) Involve the formation of opinions and the making of choices on a personal and social level	1			1	3	1		6
3) They are frequently publicized by the media with emphasis on aspects based on the interests of the media								0
4) Handle with incomplete information whether they are incomplete or conflicting scientific evidence and gaps in records	1	1		2	1	1		6
5) Deal with local and global problems and their social and political structures	1			1				2
6) Involve cost-benefit analysis in which risks interact with values		1						1
7) May involve considerations on sustainable development	6	2	3	4	2	4	2	23
8) Involve values and ethical reasoning	2	2		1		1		6
9) May require some understanding of probability and risk		3	1	1	1	2	1	9
10) They are often punctual during the transition of a life								0
<b>Total questions per edition</b>	<b>12</b>	<b>11</b>	<b>4</b>	<b>10</b>	<b>7</b>	<b>10</b>	<b>3</b>	<b>57</b>

Source: Author's elaboration.

**Figure 1.** Association between categorized issues [and their number] with potential for SSI. Source: Author's elaboration.



and the categorized variable “questions with potential for SSI”. In fact, by increasing one, the other is decreased. It means to say that the typological nature to contextualize the item may not allow SSI discussions, since it is not configured with potential for SSI. This, to a large extent, contributes to the maintenance of the difficulty of working SSI, pointed out by *Martínez Pérez & Carvalho (2012)*.

It is worth emphasizing that it is considered very important [and it could not be less] that the physics test contemplate, in its questions, quantitative, mathematical aspects and that demand contents for its resolutions. However, it is understood that the ideal is a distribution with the presence of questions that require the one who solves the test, go beyond the mere mechanical resolution, often unreflective, based on the memorization of contents and equations.

Below we will describe examples of analyzes of the selected questions (*Figures 2-4 and Boards 2-3*)

Question 58

A boy driving with his father around the city listening to the radio, he realizes that his favorite radio station, 94.9 FM, which operates in the megahertz frequency band, has its transmission signal superimposed by the transmission of a pirate radio of the same frequency that interferes in the signal of the downtown transmitter in some regions of the city. Considering the situation presented, the pirate radio interferes with the downtown radio signal due to the

- a) attenuation promoted by the air in the radiations emitted.
- b) Greater amplitude of the radiation emitted by the downtown station.
- c) Difference of intensity between the sources emitting waves.
- d) Lower transmission power of the waves of the pirate station.
- (e) Similarity of the wave lengths of emitted radiation.**

**Figure 2.** Question 58—NESE 2010—1st day SNT—Book 1—Blue (2nd application). Source: *(Brasil, 2010: p. 18)*.

**Board 2.** Analysis of the registration unit: 2010.2.A.58.E.

<b>Codification: 2010.2.A.58.E</b>		
<b>Category:</b> information of a physical nature, related to the scientific concept addressed or that are examples of applications		
<b>Potential Identifier Element for SSI:</b> Involve Values and Ethical thinking (RATCLIFFE; GRACE, 2003)		
Knowledge object (s) associated with RMSNT <sup>1</sup>	Subject (s), associated with RMSNT, explored	Context unit analysis sketch: item potential to explore SSI discussions
Oscillations, waves, optics and radiation	Wave phenomena (wave interference)	It allows discussions on ethics, values, morality, citizenship, when the statement presents the situation of a pirate radio in harm of the good transmission and reach of a regulated radio. To raise undesirable implications from the point of view of the safety of aircraft flight and landing procedures due to interference of the same nature in the radio transmitters of pilots and air traffic control towers. It also allows to relate and discuss, based on scientific and technological knowledge, the construction of elements so that appropriate measures can be taken to bring the situation to competent regulatory bodies. This situation is related to the importance of Scientific and Technological Literacy (STL) in the life of a citizen. Possible SSI: Piracy and its unwanted implications: beyond ethical issues and values.

<sup>1</sup>Reference Matrix of Science of Nature and its technologies (RMSNT). Source: Elaboration of the author, based on the research data.



**Board 3.** Analysis of the registration unit: 2015.1.B.50.C.

Codification: 2015.1.B.50.C		
Category: information of a physical nature, related to the scientific concept addressed or that are examples of applications		
Potential Identifier Element for SSI: May require some understanding of probability and risk (Ratcliffe & Grace, 2003)		
Knowledge object (s) associated with RMSNT	Subject (s), associated with RMSNT, explored	Context unit analysis sketch: item potential to explore SSI discussions
The movement, the balance and the discovery of physical laws	Kinematics applied to location	It allows discussions on technological applications that can aid in the localization of cellular telephone equipment, and as an aid element in the safety and location of users of the device or even for the recovery of theft or robbery. Possible SSI: What aspects of the technologies of a cell phone handset can be useful for security purposes and (or) your location? What health risks are involved?

Source: Elaboration of the author, based on the research data.

Item 88, above, of 2013 NESE's Physics test, as an example, does not allow us to use it as a potentiator of discussions from SSI.

## 5. Final Considerations

In this article we present a possibility of conducting qualitative research. We describe characteristics, discuss conceptual and procedural aspects of documental analysis and content analysis, generally treated as synonyms in researches, and present steps in the development of documental research. The description of this study indicates the importance of documental and content analysis in the perspective of qualitative research, which allows the understanding of the specificities present in the records and (or) in the documents, regardless of whether we use them as an autonomous method or to deepen the analyses in investigations.

As discussed throughout the study and for large-scale examinations, studies have pointed to negative developments in national examinations, including questions and related activities (Millar & Osborne, 1998; Levinson et al., 2001). In this aspect, Reis and Galvão (2008) point out that in educational systems driven by success in exams, teachers usually give little attention to topics or activities unrelated to their questions and, therefore, teaching practice tends to prioritize aspects of these tests focused on the mistaken perspective of memorization.

In addition, this section may serve as another alternative set of sources and textual genres to support the physics teacher in initiating the planning and development of his or her pedagogical activities for these purposes. This points in the direction of counteracting the difficulties of working on SSI discussions in the classroom (Martínez Pérez & Carvalho, 2012) and, to a certain extent, on the teaching practice that prioritizes aspects of evaluations aimed at memorization (Reis & Galvão, 2008).

Among the limitations of the research, we consider that in the analysis of the exam questions, our scope contemplated only one curricular component of the SNT, Physics. In spite of this, the study on the same theme, also allows to be applied to the other components, NESE's Chemistry and Biology.

For the inclusion of the STS education approach in the educational context, some actions must be planned in the face of the diversity of ways of teaching Sciences that, although often crystallized in the present curriculum in the initial formations of Natural Sciences teachers (Physics, Chemistry, Biology and Geosciences), in recent decades, have gradually gained reflective frames in the face of the academic-scientific production related to the subject matter.

In the case of NESE, we identified a set of competencies [those markedly explicit in their marking documents and reflected in Physics questions], while other competencies are absent. As an example, we lack questions that clearly seek aspects of social justice and advance the discussion about sustainability. There is a speech more focused on a green economy, but one that does not focus on guaranteeing a balanced environment so that future generations can enjoy a fair life (Nascimento, 2012). We think that the ideal would be that the elaborators of questions, not only of Physics, for the National Institute of Studies and Educational Research Anísio Teixeira (Inep), begin to consider and contemplate these competences.

It is possible and necessary to foster the development of the ability to recognize infrastructural fundamental aspects of what it is being read, so that one can surpass them and develop latent and pertinent skills, in the search of the text's objective in instigating the SSI's purpose and unfolding their discussions. The educational actions that are made up of with basic singularities currently predominate. However, we defend an educative teaching of Physics, receptive to the potentialities of interactions, among which we highlight those based on SSI discussions.

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