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Writing in Physics Classes in High School: Possibilities

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Abstract
This work explores the potentiality of writing in Physics classes by means of a didactic proposal developed in High School in Brazil, which consisted of inserting writing as a means of establishing relations of sense. It were adopted elements from Vygotsky theories (1978; 1986), assuming the importance of written language in learning process and the need for intrinsic motivation for learning; and Bakhtin theories (1986), defending language as essentially dialogical.The proposal consisted of reading texts about the history of Electromagnetism, followed by questions, and writing a letter to a scientist. Interviews were conducted with some students to understand the sense they attributed to the activity. The analysis permitted to argue in favor of writing potentiality in the learning and development processes. This experience indicates relevant discussions in favor of adopting writing activities as part of Physics teaching and learning processes.

Keywords: High school, Writing, Physics learning, Vygotsky, Bakhtin

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State of the literature
- Writing can enable the student to raise awareness and express their ideas and may even develop abstract thinking.
- Writing can be a means of production of senses and can stimulate creativity and reasoning related to scientific knowledge.
- Possibilities exist to propose writing in physics also in high school, beyond the record of information, contributing to the construction of knowledge by the student.

Contribution of this paper to the literature
- Explored writing as an important tool in knowledge building by high school students, which has not been widely researched in this level of education.

The discussion of the teaching proposal developed in the school allow to:
- extend the studies on the subject, proposing ways to deal with writing in the real context of a classroom as a means for building knowledge of physics.
- from the theoretical framework, understand writing and analyze students' productions from the perspective of interaction.
- discuss aspects of school culture that favor certain types of Physics activities in High School.

Introduction

Practices of reading and writing texts in Physics classes can be potential factors in the development of skills sought in teaching, such as scientific curiosity, critical awareness and the establishment of relationship between Science and other fields of knowledge (Almeida & Ricon, 1993; Silva, 1997; Leite & Garcia, 2009).

According to Carvalho and Barbeiro (2013), writing in the school can be discussed in different ways: as a school subject to be acquired and developed, thus the school being responsible for developing writing competences; as a vehicle for pedagogical communication, considering its aspect of transmission of knowledge and also the explicitness by students through the assessment; and a new approach is to consider its role in the development and expression of knowledge, looking at it as a learning tool.

The latter approach does not diminish the others, but expands our view on it, because it allows us to understand it as more than a tool. This approach shows that writing can be potential in rebuilding knowledge by students in many subjects.

The discussions in a more general context of the school suggest that the development and improvement of the practices of reading and writing texts is responsibility of all school subjects, not only of Language teachers (Guedes & Souza, 2011). The National Guidelines for Basic Education in Brazil, for example, reports that in High School, the political-pedagogical projects should consider, among many elements, "*the appreciation of reading and writing in all areas of knowledge*" (Brazil, 2013, p .178, our translation).

In this sense, we may question how text writing can be used in Physics classes, and how it can contribute to the process of teaching and learning this subject.

This research was developed in Brazil. Its first step was to make observations in physics classrooms, with students of the third year of High School, during two months. After, it was developed a didactic activity, that was built in partnership with the teacher. It tried to put reading and writing as auxiliary means in the construction of knowledge of electromagnetism, which was being studied in the previous two months.

Here we present the analysis of part of the materials produced by these students during the development of one didactic activity, which involves the writing of a letter to a scientist, using elements of Vygotsky's and Bakhtin's theories. The aim is to reflect on the possibilities of this activity within the conditions under which it was possible to develop it, discussing its importance in the process of education and development in Physics.

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The specific purposes of the analysis is to understand how students deal with the writing activity, and the senses they attributed to it, in the context of meanings in that such activity was developed, as well as to reflect on its limitations and improvements needed. To reach these objectives, it was set up the following specifics questions:

1) What is the relationship of the student with the activity proposed? What kinds of improvements in the didactic activity could improve such relationship?
2) What are the relationships between the utterance of the student and utterance of activities carried out previously?
3) Who is the interlocutor of the student? What senses are expressed in the letter? What voice stands out in their letters?

Background

According to Carvalho and Barbeiro (2013) several authors, such as Emig (1977) , Martlew (1983) and David (1995) , state the conception of writing as a learning tool, since they "*consider the use of written language as a factor of cognitive maturation, leading to a greater structuring of thought and, as a consequence, the development of logic-formal reasoning*" (p. 611, our translation). This conception is close to the one adopte d in this work, which is based on Vygotsky's theory, considering writing as a superior function to be developed and that can help in the construction of physics knowledge by students at school.

However, in addition to a learning tool, this study also seeks in Bakhtin´s theory, considering the context in which these practices are inserted, a perspective that appears in the work of Jewitt (2006) , for example, that emphasizes the importance of the internalization of the means to represent and communicate the knowledge of each field of knowledge (cited by Carvalho & Barbeiro, 2013, p. 613/614).

Navarro and Chion (2013) also point out that there is a vast production of writing published in Science Education international journals, at different educational levels.

However, in the review presented in this article, it was choosed to search for works developed in the Brazilian context, to understand how this practice is developed in the educational context in which this research was carried out. In this context, the literature review in Brazilian journals showed that there are still few papers focused on the discussion about the writing of texts in Physics classes in High School.

In the Brazilian literature on Science Education, it is more common to find researches about the practice of writing on Science learning in elementary school (Oliveira, 2001; Souza & Almeida, 2005; Giraldi, 2010) if compared to similar works but in High School. These studies have shown that writing, when thought as something more than a tool for reproduction of contents, can be a means of production of senses and trigger for creativity and reasoning related to scientific knowledge.

Oliveira (2001) and Giraldi (2010) have as main theoretical framework the French Discourse Analysis (FDA). Although they have different objectives and methodologies, both highlight possibilities of writing in teaching concepts of Physics in elementary school, when writing is thought of as space of significance.

Oliveira (2001) developed a proposal for teaching the subject of energy with students from elementary school, using activities of reading and writing different genres of texts. The author analyzed in students' productions the evidence of authorship, considering the influence of the readings performed, classes taught and the texts produced by the students previously. The study shows that if writing is properly dimensioned in Science teaching, it can enable the student to raise awareness and express their ideas and may even help them appropriate a more abstract thinking at this stage of schooling.

Giraldi (2010), in turn, analyzed reading and writing in Science classes in collaboration with two public school teachers. The conditions of reading and writing production were modified seeking to come closer to the authorship perspective. The paper defends that for this kind of writing to be possible in Science Education it is necessary to modify the conditions of production, which also involves working with reading.

For High School, the National Curriculum Parameters of Physics (Brazil, 2006) state that one of the competencies to be developed in Physics is the ability to "prepare oral or written communications to report, analyze and systematize events, phenomena, experiments, questions, interviews, visits, correspondences" (p. 64, our translation). In this sense, writing should also be part of classes in this subject, but this writing has to be a means of reflection and knowledge building, through the formulation of thought, when the students can also express themselves and establish relations of sense.

Regarding the writing of texts in Physics classes in High School, Paula and Talim (2015) conducted a study on the production of records in Physics classes, based on the evaluation of the students about their way of using it. The study was conducted with students from a Technical course integrated to High school. The authors discuss the roles assigned and the ways that students explain their interest in the record on their notebooks. According to the study, most students consider important the written records as a mediation to learn Physics. Three main roles assigned by students to the practice are related to learning: studying the subject later, understanding the subject, and preparing themselves for tests and assessments. The written record often seems only to help memorizing information and concepts and, therefore, it is considered important. Thus, in Physics classes writing ends up being limited to the memorization of information that will be later asked on assessments.

Trying to propose other ways of using writing in Physics classes, Charret and Krapas (2008) conducted a study analyzing, based on Bakhtin's ideas, essays on Newton's Laws written by students of the 3rd year of High School. The activity was proposed by teachers of Physics and of Writing and analysis of the texts produced was made from a linguistic point of view by the teacher of Writing and from a scientific point of view by the teacher of Physics. For the researchers, the

activity constituted a way to get to know the discourse of the student, which enabled links between school physical language and everyday language, and from there the establishment of a dialogue aimed at building knowledge.

Setlik and Higa (2014) developed a class in the first year of High School using a scientific dissemination text. After reading the text, students did a written production relating concepts studied in class and the text read, encouraging students' expression of subjectivity and creativity. In written productions, they sought evidence of empirical, formal or historical repetitions, based on elements of the French line of discourse analysis. The analysis shows that it is possible to use the written production in Physics classes as a means of building relations, express and systematize knowledge.

These works (Charret & Krapas, 2008; Setlik & Higa, 2014) show possibilities of proposing writing in Physics classes in High school, beyond the writing down of information, copying information from the blackboard/textbook or answering questionnaires, contributing to the construction of knowledge by the student. However, there are few studies with this perspective. Perhaps because of the school culture that prioritizes other processes and teaching resources, which have been historically constituted as belonging to the practices of this subject, so that writing is not commonly appreciated in Physics in this level of education.

Theoretical Framework: Writing as enunciation and incentive to reflection

Vygotsky understands human been as a social subject that, therefore, develops themselves through interaction with the social world (which enables the internalization of new psychic functions). Thus, development depends on propitious situations to learning (Oliveira, 2003). For Vygotsky, learning is not development itself, but through an organization of learning, mental development is possible, so in his theory, the learning process precedes the development one.

The development of writing skills is related to the maturation of higher psychic functions. The individual´s internal development process, that allows the acquisition of reading and writing, only occurs through the learning process of both, which is triggered in a sociocultural environment (Oliveira, 2003, p. 56/57).

According to Vygotsky (1986) writing requires the activity of speech to assume complex forms, because the situational and expressive supports are absent, thus arising the need for drafts that reflect our mental process.

Planning has an important part in written speech, when we do not actually write out a draft. Usually we say to ourselves what we are going to write; this is also a draft, though in thought only. [...] This mental draft is inner speech (Vygotsky, 1986, p. 242 / 243).

The incentive for writing in Physics classes may be important to motivate and develop the mental process of preparing drafts, whereby thinking becomes more concrete. Writing as an intellectual activity can facilitate not only teacher's monitoring of learning, for being a form of expression, but also the students to become more aware of their act of thought through the structuring of their ideas and concepts. It is important to consider that "*thought is not merely expressed in words; it comes into existence through them*" (Vygotsky, 1986, p. 218).

Vygotsky (1986) differs the so-called scientific concepts, which are developed through formal education, from the spontaneous concepts, which are related to daily life; so understanding the development of concepts requires to understand the interdependence of scientific concepts (non-spontaneous) and spontaneous ones. For him, not always can the child set the spontaneous concepts in words and operate them easily; this ability only appears some time after they have built these concepts. The origin of the non-spontaneous concepts is the opposite, as he explains:

The development of a scientific concept, on the other hand, usually begins with its verbal definition and its use in non-spontaneous operations with working on the concept itself. It starts its life in the child's mind at the level that his spontaneous concepts reach only later (Vygotsky, 1986). In this sense, he proposes that "*the development of the child´s spontaneous concepts proceeds upward, and the development of his scientific concepts downward, to a more elementary and concrete level*" (p. 193). In other words, spontaneous concepts start from an object referring to a concrete situation, while the scientific ones start from an abstraction, i.e. rely on mediation on the object, but as the child operates with those non-spontaneous concepts, they can bring them to a more concrete level.

Although these concepts are developed in opposite directions, they are closely interrelated. Gaspar (2014) explains that "*learning scientific concepts depends on the domain of related spontaneous knowledge: when there is this domain, learning occurs, when there is not, learning does not occur*" (p.133, our translation). Thus, spontaneous concepts must have reached a certain level to be able to absorb a related scientific concept (Vygotsky, 1986).

To analyze and interpret the writings produced by the students, in addition to the understanding of writing and learning process of scientific concepts by Vygotsky, elements in Bakhtin's theory were considered to help understand the language from the perspective of interaction.

The analyzes performed in this study are based on a dialogical approach to language, considering the existence of alternating voices in an utterance and understanding it, as proposed by Bakhtin (1986), as a link in the chain of verbal communication. Bakhtin proposes that the utterance is linked to other preceding (echoes and memories) and subsequent (when we prepare the utterance, we tend to assume the response of the other) utterances.

Thus, every utterance contains words of others, even if often "hidden", and with varying degrees of otherness. For Bakhtin (1986)

> *Utterances are not indifferent to one another, and are not self-sufficient; they are aware of and mutually reflect one another. These mutual reflections determine their character. Each utterance is filled with echoes and reverberations of other utterances to which it is related by the communality of the sphere of speech communication. Every utterance must be regarded primarily as a response to preceding utterances of the given sphere (we understand the word "response" here in the broadest sense) (p. 91).*

When analyzing an utterance, it is important to consider the context in which it is being structured. We must reflect on the author, speaker and utterance itself.

Thus, elements that help to understand the sense attributed by the author to the utterance made, related to their particularity and personal interests, are essential in the process of analysis. Vygotsky (1978) emphasizes that the development of writing skills is possible if there is an intrinsic need, it is necessary that the writing is a relevant and necessary activity for life. Thus it is understood that the sense that the author of the utterance (in our case, the student) gives to the activity, influences the development of their written production.

Considering the expression of the author student on the activity, it is possible to approach understanding on the importance and sense attributed by them to the activity proposed by the teacher. The way the students perceive and assign sense to the activity influences the creation of their utterance.

The interlocutor must be considered too. As stated by Bakhtin (1986), when preparing an utterance we intend to answer the other and this affects the way we structure it. Students in school activities often want to reach the teacher's expectations only; so the attitude of the teacher is determining in the deconstruction of the idea of right or wrong in this kind of activity.

The utterance is always a response to previous utterances and aims the answer of an interlocutor. According to Castro (2014), for Bakhtin vocal change is part of the structuring of our interactions, being the forms used to dialogue with others' voices variable and plastic, and can leave different evidences more or less explicit from the vocal meeting. Thus, it is not always possible to identify the different voices that make up the utterance, because the author, when taking one's word for themselves, add their own understanding and personal expression to it.

> *[...] throughout the utterance, as long as examine with care, taking into account the specific conditions of verbal communication, we will find the words of others hidden or semi-hidden, and with varying degrees of otherness. An utterance is divided into distant and almost unheard resonance of alterity of speaking individuals and into the dialogic nuances, into extremely tenuous frontiers between the utterances and fully permeable to the expressiveness of the author* (Bakhtin, 1988, p. 318 as cited in Castro, 2014, p. 41, our translation).

From this framework, this study considers important to look at how the student was able to give an active response, i.e. to understand the readings and discussions in class and to express through their personal writings, reflecting and establishing new relationships, which may indicate potential and difficulties in using these practices.

Development of the Study

This qualitative study involved different research techniques. Firstly, observations of three classes of third year of High School were conducted. Then, a teaching sequence was built in partnership with the Physics teacher, and after, it was developed in the classroom. Finally, interviews were conducted with some of the students and the Physics teacher. In this work the focus is on the analysis of letters written by the students in this teaching sequence, although elements of the interviews are considered to a greater understanding of these documents.

The objective of the didactic sequence development was to analyze how teacher and students would relate with another way of using reading and writing in the classroom. Such didactic sequence was implemented after some classes on experiments with electromagnetism, developed by the students, so it was thought to contribute to the learning of the contents that were being studied. Initially, the activity was drafted by the researcher and presented to the teacher, who made suggestions for changes that he thought were relevant to the development with his students.

The didactic sequence was organized in two main activities:

1) Reading texts and thinking about them through questions: This activity involved the reading of two texts that dealt with historical aspects of electromagnetism. We chose to use the texts from the textbook of Physics adopted at the school, being a resource to which all students have access.

After reading, students answered some questions proposed to encourage the construction of senses, and the answers were not explicit in the texts, but came from reflections on them.

There were five questions: one of the questions asked them to imagine and research about the society in which the scientist William Gilbert lived, so that the student could reflect on the context of the interlocutor of the letter that was going to be produced in the next activity. Other questions raised reflections on the changes in the society due to the development of electromagnetism field, and the possibility of knowing about the future, encouraging the imagination.

2) Writing a letter to a scientist: Developed following the first, this activity was based on writing a letter to a scientist (William Gilbert) mentioned in the texts read in the previous class, seeking to encourage the textual production of the students in a more free way. The intention was to propose a situation in which students could write what was the most significant to them, from what was discussed, presented and/or read in class during the previous two months. To prepare the letter the student could reflect, structure and organize their thoughts about the contents studied.

The didactic sequence was developed in two consecutive classes on two different days, one activity per day.

In the first class, when the texts from the textbook were read, the teacher chose to hand out the activity printed for individual reading, with no interventions with students. During the second class, when the letters were written, he made a contextualization of the activity: he told the students a story based on a fact that had occurred the day before - the power outage in the neighborhood. First, he talked about that year's Nobel Prize, which was awarded to scientists who developed the blue LED (Light Emitter Diode) – he explained what a LED is and its importance. At the time, this award was being conveyed in the news. Then he related it to the

activity, saying that a Nobel Prize of the future could be for those who invented a time machine, and joked about this possibility. He also spoke of the power outage in the area, which had taken place the day before the class. He said that it happened due to his time machine, because he tried to send an apple to the past, with a note to Isaac Newton (the amount of mass of the apple requires a lot of energy, so that was the reason for the power outage in the neighborhood). Therefore, he proposed the activity of writing a letter, which has a smaller mass, also to be sent to the past, but to William Gilbert.

The sheets were handed out with the wording of the activity and explained, in every class, that students should remember about not only the texts from the previous class, but also the experiments and discussions on Electromagnetism as a whole, which had been developed over those previous two months.

Although the activity had been performed by most students of the three classes, it was decided to conduct the analysis of the letters only of those who voluntarily participated in an interview at the end of the research, because of the possibility of interpreting more broadly the view of the student on the activity. Thus, the letters of 10 students were analyzed: S1; S2; S3; S4; S6; S8; S9; S10; S11 and S14.

From the theoretical framework adopted, some questions to guide the analysis of these productions were prepared. We sought to identify in the writing and considering elements of the interviews with these students, the following understandings:

- What is the relationship of the student with the activity proposed? What kinds of improvements in the didactic activity could improve such relationship?
- What are the relationships between the utterance of the student and utterance of activities carried out previously?
- Who is the interlocutor of the student? What senses are expressed in the letter? What voice stands out in their letters?

Analyses: Limitations and potentialities of the writing activity in the researched context

For a better display of the results, we built **Table 1** with an overview of the interpretations of students' productions. (Note: a Answers schematized from the interview; * In the student´s letters the technological change is expressed as "advance" or as a result of an advance of science. Although the authors understand the scientific and technological changes in an overlapping way, it was chosen to keep in this article the sense attributed by the students)

Discussions will be held over 3 guiding questions of analysis.

A. Relationship between students and letter writing and needed improvements

We seek to understand how students have engaged in the reading and writing activities, by analyzing whether they felt an intrinsic need to write the letter. For this, some elements expressed by the students in the interviews were used.

Most of the students (S1, S2, S3, S4, S8, S9 and S10) who wrote the letter and were interviewed said that they liked the activity because they considered it interesting. The activity was seen by some students as something different from those usually developed in Physics classes. Here are some examples of students' opinions about the activity:

Student interviewed - S4: I liked it, it was quite interesting. A different class because we do not always do these things and ... it was cool ... it was cool, I liked it a lot.

Student interviewed - S8: Oh, I liked it. Really enjoyed it. Like I said, writing is something I like. So ... and the fact that you ... it seems like you're close to what he's been through at this activity. And what this scientist has done was really great. So, I think my letter was a thank-you letter. So, I found it really cool ... this kind of work, it was something I really enjoyed.

Student interviewed - S9: I see it as a new experience for a Physics class. I found it somewhat innovative. Because I thought ... at least from what I have studied in the cram schools and such ... nothing like that, I thought it was a good idea.

Student interviewed - S10: I thought it was really cool because ... we idealize a moment like this, even if it is not possible, that we could talk to someone who was important in the past, and say that he was important, say that ... the things he helped do were important, so ... that's what I wrote in the letter, it was quite interesting from my point of view.

It is possible to observe that the subjectivity of the students influences the response given to the activity. While a student identifies himself with the activity because he likes writing (S8), others like philosophy (S4 and S9) or history (S10). Thus, imagining the possibility of communicating with someone from the past, or questioning the future, may have been interesting and meaningful to them.

The activity of writing did not have the purpose of teaching the genre Letter, but through it to motivate the expression and reconstruction of the students' ideas about the discussions and readings carried out during the previous two months. Physics classes have a repertoire of discourse genres used in the teaching-learning process. As pointed out by Brait and Pistori (2012), genres are always linked to a tradition, and are in constant transformation. The school has a culture that favors certain types of utterances that are part of the school tradition, so they make up their repertoire of discourse genres.

Table 1. Overview from a first contact with the material produced by students (Setlik, 2016).

Student	Did he/she complete the activity	Personal opinion about the activity [a]	Who was the student´s interlocutor in the letter?	Which voice stands out?	Topics discussed in the letter	Structuring of ideas	Attributed senses
S1	No	Different	Professor	Explicitly copy	Electromagnetic Induction; Lenz´s Law; Henrich Lenz	Less elaborate (copy)	To talk about knowledge (tell information)
S2	Yes	Interesting	Gilbert	Elaborate copy, coated with personal expression	Electromagnetism; Attractive Force between magnets; Faraday; Technological advance*	Better elaborate	To thank and Talk about knowledge (tell information)
S3	Yes	Different	Gilbert	Personal expression	Technological advance	Less elaborate	To thank and Talk about knowledge (tell information)
S4	Yes	Interesting/ Different	Gilbert	Personal expression	Magnetism and Electricity; Technological advance	Less elaborate	To thank
S6	Yes	Not necessary	Professor	Personal expression	Electromagnetism; Technological advance	Less elaborate	To thank
S8	Yes	Liked/ Different	Gilbert	Elaborate copy, coated with personal expression	Magnetism; What is Physics; Applications; Technological advance	Better elaborate	To thank and Talk about knowledge (tell information)
S9	Yes	Innovative	Gilbert	Personal expression	Magnetism; Technological advance	Better elaborate	To thank and Question personal doubts
S10	Yes	Interesting	Gilbert	Personal expression	Electromagnetism; What is technology and a fridge; Technological advance	Better elaborate	To talk about knowledge (tell information)
S11	No	-	Professor	Explicitly copy	Electromagnetism	Less elaborate (copy)	To talk about knowledge (tell information)
S14	Yes	Difficult	Professor	Personal expression	Technological advance	Less elaborate	To thank

Note: Table adapted from Setlik (2016).

[a] Answers schematized from the interview

* In the student´s letters the technological change is expressed as "advance" or as a result of an advance of science. Although the authors understand the scientific and technological changes in an overlapping way, it was chosen to keep in this article the sense attributed by the students.

In this perspective, students have experience with certain types of utterances in Physics classes in such a way that the act of proposing the writing of a letter may generate some difficulty in its elaboration. Thus, some students (e.g. S6 and S14) experience difficulties in writing: they didn´t see any sense and contribution of the activity in their physics learning process, perhaps because the school culture does not use these kinds of activities in the teaching of this subject. Therefore, it builds the idea that learning physics is essentially being able to perform calculations on problems that essentially involve mathematics.

In other perspective, writing a letter nowadays is not very common since other forms of written communication, such as e-mail and social networks, are widely used. Even so, some students spontaneously told us in the interview that at some point during their school time they liked to write notes to their classmates, which indicates that the letter is not such a distant genre from the reality of these students.

According to Bakhtin (1986), the genres are in a constant process of renewal. The so-called "digital genres", as Pinheiro (2010) points out, have also transformed our relationships with reading and writing. These new genres, which do not replace the old ones but transform them and make them more conscious (Bakhtin, 2008, p.340 as cited in Brait & Pistori, 2012), must be studied and included in the school because they are part of the students' experience. Thus, this activity can be rethought and restructured, perhaps using another genre instead of the letter with which some students have greater contact and mastery, which can lead to greater identification and involvement with the activity and perhaps less difficulty in writing.

B. Relationship between the utterances in the letter and the utterances of previous activities

First, students read two texts from the textbook. After, they answered some questions that had as objective to provide reflections and to create a context of meanings for the accomplishment of the subsequent activity, the writing of the letter.

The analysis of the letters indicates that the previous reading of the texts allowed the students to reflect and deepen the knowledge of Electromagnetism (discussed in various activities during the previous of two months), and more specifically, on how such knowledge was constructed over time, with the contribution of different scientists, and how the development of science provides changes in society in different ways.

Thus, we understand that the activity of reading texts from the textbook offered the opportunity for the students to come across information mainly about the historical and philosophical part of science that had not been previously discussed in the classroom. Thus, this activity was important for the writing of the letters, in which we can perceive echoes of these reflections, wrote based on the questions proposed. The technological change provided by science appears in almost every production (Table 1), so it seems to be a voice that the students have taken for themselves.

Two students (S1 and S11) wrote the letter, but did not perform the previous reading activity. Both copied excerpts from the internet to produce their letters. We interpret that the absence of this first moment of reading and reflecting (through the answers to the questions in the first activity) may also have influenced the way the letter was structured by them, causing them to fail to give an answer through the elaboration of a new utterance including their understanding. These two students made copies of texts found in other sources, and in this case, it seems that there was no involvement with the activity, and the letter interlocutor could be considered the teacher, not the scientist William Gilbert as proposed in the activity, once there seems to be no involvement of the student beyond the duty of school activity. Perhaps because they only intended to meet the expectations of the teacher, they used formal language when defining concepts, not with their own words, but by copying from other sources, without citing such sources.

It seems that the student's performance in the production of the letter is not necessarily related to an exceptional performance in the reflections from the reading of the text. It seems to be more related to the student's involvement with the proposal of the activity itself (enjoying philosophy, history or writing). In other words, the students who were better able to structure their utterances, did the first activity, but more importantly became involved in some way with the second one, expressing even during the interviews that they liked the activity and found it interesting. Thus, for these students, there seems to have been an intrinsic motivation to write the letter, as mentioned by Vygotsky (1978), assuming, although hypothetically, the scientist William Gilbert as their interlocutor.

C. Interlocutors, senses and the different voices in student's utterance

As for personal expression, according to Bakhtin (1986), it is understood that every utterance has echoes and memories of preceding utterances. What often differs is how much we fuse our voice with the different voices that compose it. Analyzing the letters produced by the students it were considered the interlocutors, senses and voices in student´s utterance. The reflections were organized in three groups: 1) Copies and Repetition; 2) Personal Expression, and 3) Personal Expression with intrinsic motivation.

C.1) Copies and Repetition

Students S1 and S11 just copied, that is, they wrote their letters by repeating, in its entirety, excerpts of texts available on the internet. S1 did the activity in the classroom while S11 did it at home. In these cases, students did not put their personal expression into the utterance and writing did not seem to be a process, as proposed by Vygotsky (1986), but a manual repetition of letters. Although the copy may also allow these students to reflect and somehow systematize the content, the lack of expression and personal understanding may indicate that for them the previous activities were not enough to elicit senses, and therefore for the elaboration of an utterance as an active response that comes from their understanding, as proposed by Bakhtin (1986).

C.2) Personal Expression

Students S2 and S8 have copied information from other sources, but this copy was used in a personal construction of the utterance.

Students S3, S4, S6 and S14 were able to include their understanding and personal expression on the utterance, but their letters did not have a greater elaboration or structuring (since in their writing the student does not use or detail information). They created their letters without further explanation of concepts, scientists, or experiments previously studied. It is emphasized that the students had the freedom in the creation of their letters to insert information and details according to their particularity and their personal interests.

In general, in these productions students thank William Gilbert and speak briefly about the technological advances of the current society. In most letters this last aspect seems to be the predominant voice, being echo of the readings and reflections carried out in the previous classes.

Student S3, for example, shows in his letter the advance in science, and reports that there were contributions from several scientists after Gilbert, who allowed such advance. This element is somehow presented in the texts read, aspect that until then, had not been discussed in the classroom before the activity of reading.

Writing in these cases seems to allow the student to express a synthesis of their reflections on the evolution of science and the importance of different scientists in scientific discoveries.

In some of these letters, for example those of S4 and S6, the ideas expressed are unclear, giving rise to the interpretation that they have not yet appropriated concepts studied. In the interview, student S4 confirms that he had difficulties in interpreting the texts read in the previous class, due to lack of previous knowledge about the scientists and experiments, although these discussions had already been mentioned in previous classes, in the presentations of the experiments by the classmates.

Although in these productions the utterance is permeated by the expression of the student, the presentation of ideas in a vague way can also indicate difficulties of personal understanding, of giving a response with greater structuring and organization, and perhaps in this sense, the previous activities and readings were not enough for the appropriation of concepts. Hence the importance of proposing new types of activities, such as writing, in order to provide the students with new situations and opportunities for reflection and deepening of their knowledge.

Vygotsky (1986) draws attention to the interrelation between scientific and spontaneous concepts. Daily applications were recurrent examples in the discussions held in previous classes, but scientific concepts have not always been well defined and systematized. So the students, given the time available and how the teacher chose to work - through discussions - did not have so many opportunities to operate with these concepts of electromagnetism in other ways, such as through exercises. For Vygotsky (1986) the learning of concepts can also occur from the abstraction of scientific concepts, through words, which are then approximated to their spontaneous related concepts.

In another perspective, Irigoite (2012) argues that many students write with artificiality of content, because there is often no interlocutor in these school activities, causing them to write to the teacher only, that is, the students do not envision a broader interaction.

C.3) Personal Expression with intrinsic motivation

Students S2, S8, S9 and S10 were the ones who were better able to structure and organize their letters. These students showed interest and were involved in the activity proposed, it seems that there was an intrinsic need and their interlocutor was William Gilbert. To create the letter, they seem to be inspired by the discussions held in the classroom and the texts read. It is perceived that they were able to include their personal expression in the utterance. Thus, although it happens, the vocal meeting in these productions is not evident.

Writing in these cases allowed the students a personal expression taking different voices for themselves, once from utterances of previous activities, such as the reading of texts and discussions made, these students sought to build their own utterances and also organize their letter in a logical sequence. The written production seems to have been a significant activity in the reflection on the studied concepts and mainly in the incentive to the expression of their creativity and personal relations of sense.

Take, for example, student S8's letter:

> *Dear William Gilbert,*
>
> *I'm sending you this letter to say thank you. Your studies have made changes to many things around here in my time. Your work was of extreme importance since from them many scientists were able to develop great things and their studies on magnetism opened doors to its development.*
>
> *Nowadays, physics, which is the science that aims to understand the phenomena mainly related to the interactions between matter and energy, values your work.*
>
> *Magnetism has helped a lot people's lives, making it possible to use engines of several kinds, guides such as the compass and much more. Thanks to the magnetism we have electric energy. Magnetism is everywhere and it was the basis of all technological evolution, or almost all; since then, its use has become practically unlimited, both in simple things, such as mixers, and also in more complex things such as electrons control systems.*
>
> *Therefore, congratulations and thanks, the work you have left for us was of great importance*. (Our translation of the Letter written by Student S8)

Student S8 first writes an introduction in which, taking the word in the first person ("I am sending you"), he addresses directly to the scientist ("your studies") highlighting the contributions of Gilbert's work to further developments in science. This work is mentioned in the texts that were previously read, as well as other scientists and experiments/concepts that were constructed after the work of Gilbert. There is a responsive understanding of the readings of texts that produce echoes in that student's utterance.

After the introduction, S8 explains to Gilbert what Physics is, justifying that this science gives a lot of importance to their studies. The student makes reference to the interaction between matter and energy, as well as to the application of magnetism in "electron control systems". In this particular case, it could be utterances that the student had heard or read elsewhere, outside the classroom, since this information is not explicitly present in the texts previously read and was not discussed in class in other activities during the period of two months. Other points mentioned by the student, such as motors, electric energy and compass, were present in the texts indicated for reading and/or were discussed in class.

Although in the interview S8 mentioned that he had difficulties understanding the texts read because he did not like science history so much, he seems to have been able to think and organize his ideas in a more logical and detailed way than other students, perhaps because of his pleasure of writing. He says he liked the activity since he could express his feelings more freely. Thus, it seems that he does not have the concern with detailing concepts or information, but with expressing his point of view in a more general way, perhaps also because of the many possibilities of writing that the activity provided.

Another example is student S9 letter:

> *Dear William Gilbert,*
>
> *I hereby would like to question, thank, and even inform you of some things. As you may have noticed, this letter is at least strange, for it comes from the future. This is due to the evolution of your study on magnetism. It was Jamieson who created it.*
>
> *I would like to ask you where the geniality of studying magnetism came from. Because of your study, today we have many experiments, technological advances. Even the science of medicine was able to develop a little. I believe that if the scientists from the 21st century could send you letters, you would receive lots with words of thanks and questions. I finish this letter with a question waiting for its answer: Where did the idea of earth's magnetic field come from?*
>
> *Thank you* (Our translation of the Letter written by Student S9)

Student S9, in turn, also seeks to use a logical sequence in his utterance, but made the option of questioning the scientist about one curiosity. Also in the first person, he begins with an introduction, talking about the reason of the letter and where it is being sent from, so there is a vocal meeting with the teacher's speech, used to motivate the activity. He then talks about technological advancement, thanking Gilbert, and finally asks the scientist a question about the earth's magnetic field. He wants to know, more precisely, how Gilbert elaborated this idea. This appears in the text read in the classroom, but the answer to the question is not explicit (note: the teacher did not deepen this discussion in previous classes). S9 frequently asks questions and actively participates in classes, and stated in the interview that he likes subjects such as history and philosophy, which may justify his choice for questioning the scientist.

Finally, one more example is student S10's letter:

> *Dear William Gilbert,*
>
> *I hereby would like to bring a little knowledge of the future and thank you for being such a committed and hard-working person in your studies, because they had served as a basis for further studies about electromagnetism, surprised? Yes.*
>
> *You were one of the pioneers of a big part of the technology that we have today, technology is the word used today to describe the advance of humanity in general knowledge about our land. Many things have changed and to describe each of them would take a long time, but since you were a scientist dedicated to physical concepts, it was through physics that we developed our technology drastically. Today we have the so-called home appliances to help us with our tasks in our homes, the appliances are machines created from physical experiments, an example is the refrigerator, this appliance keeps the food cold and refrigerated, making it last much longer while preserving the quality of food*. (Our translation of the Letter written by Student S10)

Students S9 and S10 clearly express to think in the scientist Gilbert as the interlocutor of their letter, since they put themselves in the place of this interlocutor creating situational supports in their writings.

Student S10 throughout the utterance seems to think of the interlocutor of the letter. He imagines that Gilbert would have a surprise hearing about Electromagnetism, which may indicate some understanding of the scientist's contributions. This student seeks to explain with his own words what technology is and the function of a refrigerator, without detailing concepts or any experiments carried out. He also speaks of technological advance, thanking the scientist. There seems to be a responsive understanding of the readings of the texts and of the examples used in the classroom by the teacher (in previous classes he used the example of the refrigerator when talking about electric energy), which produces echoes in that student's utterance, elements that show his personal expression.

For these students it seems that the activity contributed for the consciousness of the importance of science, especially the development of electromagnetism in the "advances of humanity" – in the words of student S10. However, the large number of possibilities that the activity provides seems to lead to the production of a letter with less detail of information.

In almost all letters one sense is recurrent: scientific knowledge provides technological advancement. This is a discussion that often appeared in the classroom during the previous two-month period and echoes most significantly in the students' utterances. The teacher used as a justification for the development of the activity the story of a time machine capable of carrying the letter to the past, and the students, in the previous class, imagined what the future would be like. In this way, in general, they seemed to associate, when writing, the new technologies to the scientific advance by the very conditions in which the utterances were produced.

Final Considerations

It is possible to observe that the students had different performances in the activity and that they had difficulties in writing about Physics. In most letters the specific concepts of Electromagnetism appear vaguely or do not appear, which on the one hand may indicate that the learning of these concepts is still in process, and it is not yet possible to operate with them through writing. On the other hand, by adopting writing as a privileged means to reflect and to make the thought more concrete, it is understood that the very attempt to operate with such knowledge through writing is a process that can lead to its development, an idea that was also expressed by some students in the interview.

From Vygotsky's works (1986), it is clarified that the activity of reading and writing was aimed at helping the student to operate with the knowledge studied in different ways, allowing them to reflect on their thoughts about these concepts, making them more concrete and defined. That is, by contributing to the movement of approximation between scientific and spontaneous concepts, through the expression of their attributions of meanings.

As evidenced by the work of Charret and Krapas (2008), writing can establish links between the language of school and everyday physics, encouraging a dialogue for the construction of knowledge. As Gaspar mentions (2014), according to Vygotsky's theory, mastery of content depends on the students acquiring or constructing a mental structure and this demands time and effort from the students themselves (p. 205). In this sense, it takes time for this development, operating with the knowledge of different forms and getting involved in the activity.

According to Jobim and Souza (2008), based on Bakhtin, the more we express our ideas, the better we formulate them within our thinking (p. 112). It is necessary to create situations in the classroom where the student can express their knowledge about Physics, and writing can be used as a potential medium. As Vygotsky (1986) points out, writing differs from speech, because it requires more complex forms, since there are no situational and expressive supports.

In this particular activity, four students seemed to use writing to establish and express personal sense relationships. They reported that the activity provided them with new reflections on the content. Thus the activities of reading and writing allowed them to know a little of the history of Electromagnetism and to reflect on the construction of knowledge and its importance to society. The difficulty in writing is not a surprise, just like some students have difficulties in other types of activities. Writing can contribute to the development of different skills, as well as encouraging reflection and structuring of thinking about physical concepts through words. As stated by Vygotsky (1986): "Experience teaches us that thought does not express itself in words, but rather realizes itself in them" (p. 251), or as put by Gaspar (2014): "thought does not exist independent of the word, it does not use it only to be expressed, thought exists because the word exists" (p. 89, our translation).

Writing in Physics Classes in High School: Possibilities

Perhaps the activity could have been more meaningful if another genre of writing were proposed (e-mail, text for blog, for example), or another interlocutor for the letter (instead of a scientist from the past, someone who had social, political or cultural involvement with the context of the students, such as politicians, non-governmental organizations involved with the environment, or even someone from the student's family).

It is also important that writing be worked on more extensive way, in different classes so that students can develop this ability by correcting and improving their writing, although it is not always possible to use reading and writing systematically in a sequence of lessons. In this research we tried to insert writing within the concrete conditions of the school context investigated. The teacher had an activity plan with experiments and discussion classes, in which writing were also present, but predominantly through copying or taking notes of information. It was possible to develop an activity that could be improved, but that allowed some students to use writing as a means of establishing relations of senses and expressing themselves in a freer way.

As this type of activity becomes part of the subject's culture, more students may become involved and potentially use writing for their learning. It is important to think of activities that use writing to structure and organize students' thinking, not as the only activity of the subject, but within the context in which it occurs. This activity shows that in the middle of exercises, problems and experimental reports it is possible to develop new ways of working with writing that allow different possibilities to establish relations on meaning and reflect on Physics.

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