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Contributions to the teaching of physics in the final years of elementary education through the collaborative production of animations

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ABSTRACT

The teaching of Physics in the final grades of Elementary School is a challenge, both for the training of teachers and for the mediation of the contents themselves, having as reference the National Common Curricular Base (BNCC). This article aims to raise the potentialities awakened in students by the collaborative production of animations to teach Physics concepts in the 9th grade of Elementary School. The research carried out is of a qualitative nature, as a case study, and was carried out in a school of the Municipal Education Network of Curitiba with 23 students from a 9th grade class. For this, a didactic-methodological strategy was developed based on collaborative production with the use of digital technologies, having as a reference Coll, Mauri and Onrubia (2010). Five animations were produced by the participants, which were analyzed in the light of the interactive triangle proposed by Coll, Mauri and Onrubia. The results obtained demonstrate that this strategy helped in the constructive activity of the students and provided a broader view of the physical phenomena worked in the classroom. From the textual analysis of the results, it is considered that the didactic-methodological strategy used in this research can contribute to the approach of Physics contents at this stage of teaching, in addition to allowing the student to be introduced to these themes in a different way from the conventional.

KEYWORDS: Collaborative learning. Stop motion. Science Teaching. Elementary School.

INTRODUCTION

Addressing specific topics of Physics in the 9th grade of Elementary School is one of the main difficulties historically presented by Science teachers in Brazilian basic education (MELO; CAMPOS; ALMEIDA, 2015). Some factors can be listed to try to understand the difficulty of working with such contents in Elementary School, such as, for example, the training of teachers, which is often not specific in the area, being mostly in the field of biological sciences. As a result, some professionals end up prioritizing content in the area of biological sciences, to the detriment of content in Chemistry and Physics, with negative consequences for the training in these sciences of students in the 8th and 9th grades of Elementary School (MASSONI; BARP; DANTAS, 2018).

In view of the implementation of the National Curricular Common Base – BNCC (BRASIL, 2017) throughout the national territory from 2020 onwards, it is clear from the analysis of the document that the contents of Physics, previously formally addressed only in the 9th grade of the Elementary School and indirectly in other stages, started to be present in all stages of Science teaching. In this way, it becomes crucial that teachers who work at this level of education have increasingly diversified strategies and methodologies to work with such contents, in addition to this scenario representing a new challenge for the training of teachers of basic education.

Allied to this difficulty, research in science education and teaching points to a need for a change in the performance of the teacher in these areas, based on the assumption of a goal of mediating science for all student profiles and directing them to a critical appropriation, so that science and technology are effectively incorporated into the universe of social representations and constitute themselves as culture (DELIZOICOV; ANGOTTI; PERNAMBUCO, 2011).

In this work, it is considered that Digital Information and Communication Technologies (DICT) can bring contributions to teaching and learning, when incorporated into collaborative productions, in addition to favoring teaching aimed at the student. According to Sobreira (2017), productions that challenge students' authorship can help them to develop autonomy, both in individual and collective projects. Furthermore, it is understood that a didactic-methodological strategy anchored in collaborative and technological processes can expand the possibilities of approaching Physics in Elementary School, as an alternative to the aforementioned difficulties.

Attempts to seek new ways to reach students constitute a challenge that teachers need to overcome daily, either because of the students' lack of motivation, or because of the adoption of new technological tools, such as the ubiquitous smartphone, which, due to the lack of a methodology in its use at school, ends up becoming a disperser of attention and is not used as an ally in the learning process. On motivation in science teaching, Delizoicov, Angotti and Pernambuco (2011) state:

> Making the learning of scientific knowledge in the classroom a pleasurable challenge is to make it meaningful for everyone, both for the teacher and for the group of students that make up the class. It is to transform it into a collective project, in which the adventure of searching for the new, for the unknown, for its potential, for its risks and limits, is the opportunity to

> exercise and learn social relationships and values (DELIZOICOV; ANGOTTI; PERNAMBUCO, 2011, p. 153).

Thinking of a way to use the potential of technological artifacts, allied to a theoretical-methodological basis, this research aimed to investigate whether the mediation of Physics contents, through the collaborative production of animated videos by students, allows a better appropriation of the themes and a greater predisposition for learning. With that, the objective of this work was to identify potentialities of the collaborative production of animations for the teaching of Physics in the 9th grade of Elementary School.

Based on collaborative activities, it is possible to provide students with a space to express themselves and develop their orality, because, in these work groups, communication between students is expanded, compared to discussion scenarios with the whole class (COHEN; LOTAN, 2017). For these authors, group work approaches the dynamics used in scientific investigations, allowing students to investigate, collect data and argue, allowing them to learn the **language of science**. However, Cohen and Lotan (2017) emphasize that having students in groups is not enough to obtain learning gains, and clear planning and objectives are necessary to propose such dynamics.

In this way, collaborative activities need to be planned and structured to allow an open learning process, in which students negotiate with each other, assess whether objectives have been achieved and assignments intertwine, with the teacher playing a mediation role, enabling the development of student autonomy (TORRES; IRALA, 2014).

Despite the advantages observed in collaborative activities, this research intended to incorporate such benefits into a didactic-methodological strategy that integrates DICT, through the production of animations for these tasks of a collective nature. The *stop motion* technique was chosen for the realization of the animations, due to its versatile character, as it is a good resource to be used in simple and low-cost animations, for various purposes, including didactics (FERREIRA, 2016). *Stop motion* consists of photographing objects in fixed positions and creating, through the succession of images, an illusion of movement (MAGALHÃES, 2015).

For Wishart (2017), *stop motion* helps in the process of representing scientific knowledge and the process of creating animations is useful to support learning and reinforce scientific concepts learned in class. In addition, the author points out that animations help teachers in the reflective process about the ways used to communicate and disseminate science to other people.

DICT AND THE INTERACTIVE TRIANGLE

Despite the popularization of computers and digital technologies in general in schools, from the 1990s onwards (FIOLHAIS; TRINDADE, 2003), the number of computer labs and computers in schools is not enough to meet the needs of students; according to the 2018 School Census, 44.3% of elementary schools have a computer lab, with only 35% of them managed by municipalities (INEP, 2019), evidencing the low number of these important learning spaces in educational institutions.

It is also necessary to give special attention to the formulation of public policies for the insertion of technology in education, regarding the training of teachers, the adaptation of formal and non-formal teaching spaces and, mainly, its reception by the school community, under penalty of having initiatives that suffer discontinuities or are simply not appropriated by the community (MONDINI; SAAVEDRA; MERKLE, 2016).

To try to circumvent this reality, mobile devices (*smartphones, tablets*, etc.) appear as a possible solution, in some situations, for the lack of computers for all students. According to Borba and Lacerda (2012), these devices can be used to support face-to-face teaching, while the internet provides individual assistance to the student, but it is important to take into account the negative aspects that the incorporation of these materials can raise. For the authors, issues related to addiction in the use of these devices are already being raised, demonstrating the need for a deep investigation of these aspects.

According to Sullivan *et al.* (2019), the mobile devices that students carry have sophisticated features and can be used to provide personalized, collaborative and authentic learning. Considering that information technologies are part of children's natural environment and their universe of socialization, the adult and the educational institution have in their hands the ability to act as mediators to enable new ways of learning, the development of critical thinking and the creative use of these technologies (BELLONI; GOMES, 2008).

To make this combination of collaborative activities, based on the use of DICT in Science teaching, the elaboration and application of the didactic-methodological strategy proposed in this work was based on the **interactive triangle** of Coll, Mauri and Onrubia (2010). For these authors, due to their intrinsic characteristics, DICT can function as tools capable of mediating the psychological processes involved in teaching and learning. This function attributed to technologies is fulfilled when they mediate the relationships between the three elements of the interactive triangle – student, teacher and content –, contributing to the formation of the activity context in which these relationships occur (COLL; MAURI; ONRUBIA, 2010). Still for the authors, DICT can play an important role in mediating the interactive triangle and this relationship can be classified into five different categories, according to the summary presented in Chart 1.

Chart 1 – DICTs as mediators of relationships in the interactive triangle – categories

DICTs usage categories	**Usual examples of DICT usage in this category**
1 - DICT as mediators of relationships between students and learning content.	- Search and select learning content; - Access to content repositories.
2 - DICT as instruments of relations between teachers and teaching and learning contents.	- Search, select and organize teaching content; - Access to repositories of learning objects; - Preparation of records of teaching and learning activities carried out by students.

3 - DICT as mediating instruments in the relationships between teachers and students or between students.	- Carry out communication exchanges between teachers and students or between the students themselves that are not directly related to the contents or to the teaching tasks and activities.
4 - DICT as mediating instruments of the joint activity developed by teachers and students during the performance of teaching and learning tasks or activities.	- As auxiliaries or amplifiers of certain actions of the teacher and students (explain, illustrate, relate, etc.); - For the teacher to monitor the progress and difficulties of the students; - For students to follow their own learning process.
5 - DICT as tools to configure environments or work and learning spaces.	- Set up individual *online* learning environments or spaces; - Set up *online* collaborative workspaces or environments.

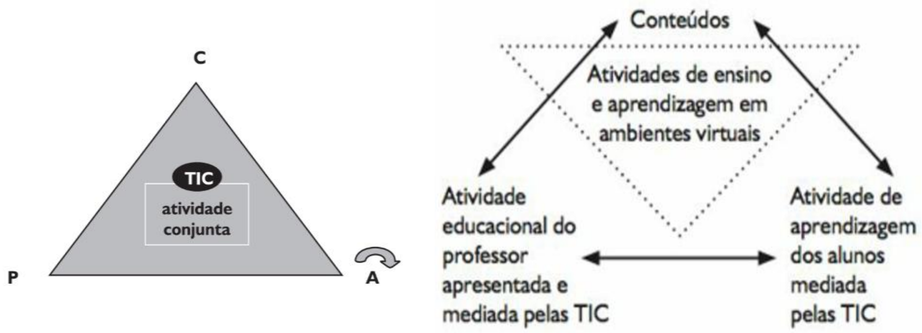
Source: Coll, Mauri and Onrubia (2010).

It should be noted that, according to the authors, these categories are not presented in a specific order from the point of view of their educational value or their ability to promote processes of transformation, innovation and qualification in education. In addition, relationships may vary, and changes and evolutions may occur in one or another direction.

The interactive triangle represents a necessary interrelationship between educator, student and content, in which relationships are established so that both the student and the teacher are builders of knowledge, bringing educational meaning to both (SILVA; RAMOS, 2011).

Thus, according to Coll, Mauri and Onrubia (2010), in this triad, the following are present: the **student**, who learns by developing his mental activity of a constructive nature; the **content**, which is the object of teaching and learning; and the **teacher**, who helps the student in the process of building meanings and attributing meanings to the learning content (Figure 1).

Figure 1 – Interactive triangle and learning as a result of an interactive relationship



Source: Coll, Mauri and Onrubia (2010).

According to Coll, Mauri and Onrubia (2010), in this interactive triad, digital technologies (the authors use ICT, in Figure 1, with the same DICT concept used in this article) can help overcome a conception of knowledge and learning. basically individual, moving towards a constructivist and sociocultural conception, understanding learning as the result of an interactive relationship, factors that are corroborated by Angotti (2015), when placing the teacher as an indispensable epistemic subject in the mediation of the teaching and learning processes, besides:

> Recognizing the learner as a subject of learning means considering that teachers have an important role in helping them in their learning process, as the main mediator. We preferentially insist on technological mediations, through free and open DICTs (ANGOTTI, 2015, p. 9).

In the author's view, mediation through DICT, in addition to fostering student autonomy, has the potential to foster dialogic relationships between students and their peers and teachers, decisively impacting student learning.

METHODOLOGY

The methodology used in this research was based on collaborative production from the interactive triangle, seeking to analyze whether mediation by DICT can help in the teaching and learning process, involving the three elements of the triad: students, content and teacher.

This research is configured as qualitative, through a case study, with the teacher/researcher in direct contact with the participants. The instruments used for data collection were: participant observation, notes, audio recorded in the classroom, students' notebooks and script of the animations produced by them.

The work was carried out in a school of the Public Education in the city of Curitiba. The school is one of 11 units that serve students from the 6th to the 9th grade of Elementary School and is located in the Fazendinha neighborhood. The group of research participants was formed by a 9th grade class, composed of 23 students. The research took place during Science classes, in the second quarter of 2019, in the months of May and June, and was authorized by the opinion of the Ethics Committee in Research Involving Human Beings of the Universidade Tecnológica Federal do Paraná (UTFPR), under no. 3,325,096/2019.

Students were divided into teams of four to five, with the aim of making the composition of the groups more heterogeneous and aiming at teaching and learning equity in the classroom (COHEN; LOTAN, 2017). With this in mind, the ordering by academic *status* of students was the main criterion used for the formation of groups, based on the recommendation made by Bianchini (1997), to prevent students of medium or low academic *status* from being harmed in the development of activities. In this way, the groups merged students with heterogeneous academic performances, to prevent, otherwise, eventual groups formed with only students of high academic *status* from developing activities with greater ease than eventual groups composed of students with medium or low academic *status*, which could lead to distorted or misleading analysis of results. In total, five teams were formed with the participants, three groups of five students and two groups of four students.

The strategy used by the teacher/researcher for the participants to plan their animations was the construction of a script, in which the students would determine in advance the technical aspects of the product. The short film animations should address Physics in the student's daily life, that is, the students were challenged to reflect in which everyday situations they recognize the concepts of Physics worked in the classroom by the teacher and how to use the *stop motion* technique to transpose the knowledge acquired in the classroom to animation.

For the production of animations, the teacher/researcher provided the students with the necessary materials, such as a *smartphone*, a camera, computers for editing, lighting and a tripod for the camera, in addition to different materials for the composition of the scenarios (modelling clay, papers, scissors, ink). In addition, students were allowed to use personal equipment for recording and editing the animations. For editing the animations, computer programs and *smartphone* applications were suggested and the students were free to choose the *software* that would best apply to their production.

Each research participant received a notebook for individual notes. At the last meeting, the teacher/researcher collected all the notebooks to analyze the notes taken. The activities were developed in nine classes, as shown in Chart 2.

Chart 2 – Schedule of meetings and data collection

Class	Date	Research Methodology	Procedures	Data Collection
1	05/16	Guide students in the classroom about the research that would be carried out.	Delivery of terms (ICF and TCUISV) to research participants.	Organização dos alunos em fileiras e leitura dos documentos para a realização da pesquisa. Esclarecimentos de dúvidas sobre os procedimentos da pesquisa.
2	06/04	Guide and coordinate students in individual.	Records in notebooks about everyday situations in which they recognize the concepts of Physics studied in class in the first quarter of the year.	Participants received an individual notebook and wrote down everyday situations in which they recognized some concepts studied in the classroom. Analysis of the notes to verify if the students were able to make this relationship. There was no need to resume content or include previous organizers. teacher/researcher notes were performed in an observation protocol.
3	06/06	Instruct research participants on *stop motion* and *pixilation* techniques.	Presentation of *stop motion* and *pixilation* techniques and resources needed to produce a low-cost animation.	The students were introduced to the *stop motion* technique. Gradually, they related the filming technique to some cinematographic productions. The information collected was recorded in the researcher's observation protocol.

4	06/07	Organize research participants for collaborative activities, according to criteria defined by the researcher.	With the help of the teacher/researcher, the students organized themselves into teams and started a discussion about the situations they described in class 2.	The teacher/researcher used the academic level criterion to organize the teams. Each team should contain at least one student ranked with a high academic *status*. The academic performance *status* analysis was previously performed. The teacher/researcher asked the students to exchange their notebooks with the team members so that they could read the notes from the previous class. Data collection made by annotations in the observation protocol and audio recording of the participants.
5	06/11	Assign students to research activities. Manipulation of simulators and collection of information for the production of the script.	In the school's computer lab, each team used three computers to carry out their research and collect data for the production of the animation script.	Manipulation of simulations for the teaching of Physics of the PhET project and collection of information for the production of animations. While the students manipulated the simulators, the teacher/researcher assisted the teams. Records of notes in the observation protocol and audio recording.
6	06/13	Coordinate students in the collaborative production of a script for the animation.	In their teams, equipped with individual notebooks, the students prepared a script for the production of animations.	O professor/pesquisador orientou os alunos a escolher uma situação descrita nos cadernos de anotações para elaborar um roteiro. Foi possível verificar se os alunos estavam realizando a transposição dos conceitos aprendidos em sala para o roteiro. O que fosse relevante para a pesquisa era anotado no protocolo de observação.
7	06/18	Guide and organize students for the production and editing of animations in the computer lab.	Following the script produced as a team, the students produced and edited the animations.	Participants captured the images and edited the animations. Computers with the Shotcut *software* installed and the *Stop Motion* Studio *app* for *smartphones* were made available. It was possible to observe the collaborative activities of the students and make notes in the observation protocol, in addition to recording audios.
8	06/25			

9	06/27	Provide a moment for students to present the animations they produced and evaluate the final product.	Describe in your notebook, individually, what your animation is about. Presentation of the animations produced in teams for the whole class.	Each student described in his notebook the animation he produced as a team and the concepts of Physics addressed. Afterwards, the teacher/researcher collected the notebooks. Afterwards, the students presented their animations. It was possible to evaluate the orality of the participants and if there was an appropriation of the concepts learned from the animations produced. For data collection, the observation protocol and audio recording were used.

Source: Authors (2019).

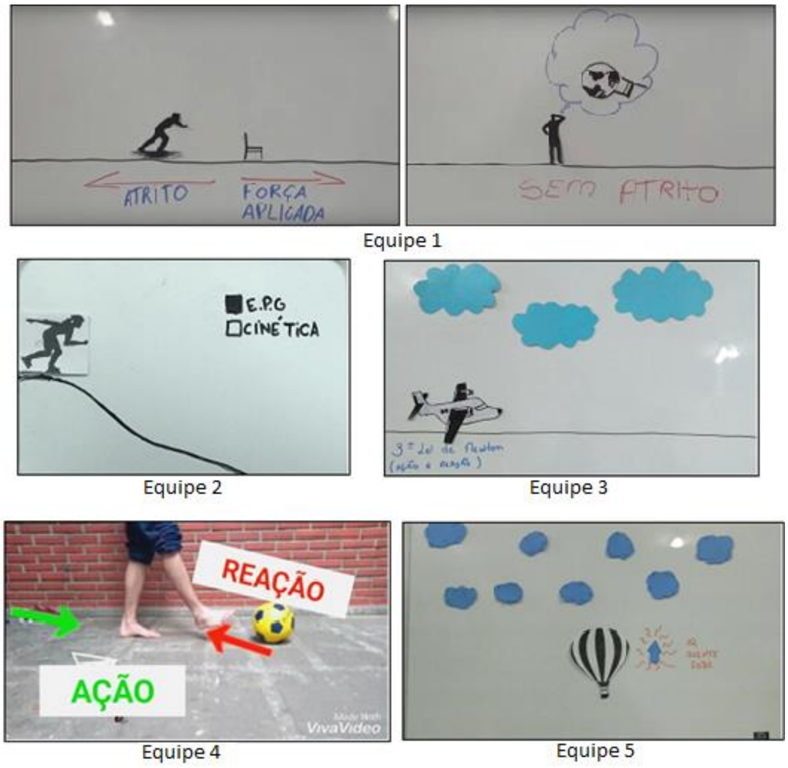
Notes were taken during the meetings and, when it was not possible, the researcher recorded them in the observation protocol at the end of the classes.

RESULTS AND DISCUSSIONS

Data analysis was performed based on observations, notes made by the teacher/researcher and audio collected during the activities. The notebooks, the scripts developed by the students for the production of animations and the animations that the students produced were also analyzed, in order to identify the potentialities awakened in them by the collaborative production of animations for the teaching of Science in the final years of the Elementary School.

For the application of the didactic-methodological strategy, nine meetings were planned with the students. For research purposes, in which it is necessary to apply the activity and, at the same time, perform an accurate observation and collect data during the execution, this number of classes was sufficient. In all, five animations were produced by the students (Figure 2) and each team was categorized with the number from 1 to 5. Within the teams, each student was identified with capital letters (A, B, C, D, E). Therefore, when bringing the participants' report to the analysis, they will be identified by the team number and differentiated within the team by a letter (for example, Student E4A, Student E1B, Student E2A).

Figure 2 – Animações produzidas pelos alunos



Source: Authors (2019).

After guiding the students in the first meeting about the activities that would be developed during the research, each participant received a notebook from the teacher/researcher and all were directed to answer in this notebook the following question: **in which everyday situations do you identify concepts of Physics studied in science classes?** These notes would be taken up again in class 4, in a collaborative activity, and the notebooks delivered to the students would be used as a diary of notes and collected at the end of the research, for an accurate analysis.

Making the relationship between the concepts of Physics studied in the classroom and everyday situations represented a difficulty for the students, requiring the intervention of the researcher to bring some examples to the discussion and make them more comfortable to take their notes. Based on the perspective of the **interactive triangle**, the initial classes demonstrated the importance of the joint relationship that must occur between student-teacher-content in the teaching and learning process, because, from the proposed activities, the teacher was able to help the student in the construction process. of meanings and attribution of meanings to the learning contents, bringing the concepts learned in the classroom to a reality closer to the student.

In class 3, the students received technical guidance for the production of a *stop motion* animation and, in the sequence (class 4), they organized themselves into teams to resume the discussions of the second class, but this time in a collaborative way. At this stage of the research, it was possible to perceive the difficulty that some students had to discuss their ideas with other colleagues, either because of shyness or insecurity in their answers; therefore, the intervention of the teacher/researcher was essential to help the teams, including to prevent students from deviating from the main objective of the activity, which was the production of knowledge in a collaborative way.

At this stage of the research, the importance of the teacher in building conditions for the development of group work is highlighted, since the creation of these collaborative work spaces in Elementary School can encourage social interaction and the exercise of mutual help, generating possible gains in learning (RAMOS, 2007).

Following the activities, the students were presented with some simulations for teaching Physics from the PhET1 project, at the University of Colorado, in Boulder, so that they could collect some ideas for the material they would produce. After this research process, in the school's computer lab, they started producing a script for the animations. At this point, it is important to emphasize that the **content** has an essential aspect in the **interactive triad** and cannot be left out in the inclusion of DICTs in the classroom. For this reason, in the script model presented to the students, they were challenged to develop a plot and include the concepts of Physics that would be present in the animation.

At this moment, it was possible to notice that some concepts learned by the students previously started to be remembered when worked again and in a collaborative way. The collected data evidence this aspect; for example, in the animation produced by team 4, the conceptual error was noticed when watching the finished video.

The animation was described by Student E4C in the notebook as follows: “[...] we use a ball and a person to demonstrate Newton's 3rd Law (action and reaction). We used an application to edit the video, proving that for every action, there is a reaction, with the kick being the action”. The students explained that, initially, they had indicated the action in the kick and the movement of the ball in the same direction (reaction), but they decided to consult the textbook, as they had doubts about the representation.

After watching the video and talking to each other, they realized that they should correct the position of the vector and, when explaining the mistake they made in class 9, they informed that, in the final product, the intention was to show that the foot exerts a force on the ball (action) and the ball exerts the same force on the foot (reaction).

These data corroborate the understanding of Martins (2016), in the sense that didactic activities that value mediation by DICT, collaboration between peers and personalization actions in teaching allow the establishment of new situations for the formation of concepts, different from those observed in a traditional class, based only on the exposition of contents and mere transmission of knowledge (teacher-student), evidencing an attribute of the new relationships created in a learning process that involves the three parts of the interactive triangle.

Regarding the materials used by the students to carry out the animations, there was a preference for the use of *smartphones* to capture images, to the detriment of the camera. What helps to understand this choice is the possible familiarity that these students have with the equipment available, as *smartphones* are more present in their daily lives. According to data from the Continuous National Household Sample Survey (PNAD Contínua; IBGE, 2018), cell phones are present in 93.2% of households in the country; in addition, among the main internet access equipment are: computers, with 52.3%, and cell phones, with 98.7% of use for this purpose. As for the population aged 10 to 13 years, 71.2% use the internet and this percentage increases to 84.9% in the population aged 14 to 17 years old.

Resuming the analysis of the animations, team 1 brought a production that dealt with the topic of **friction**. The students intended to demonstrate what would happen to a chair if, after the person pushed it, the friction force was eliminated, as can be seen in the report of Student E1C, from the notebook: “The man pushed the chair and the chair stopped, it means friction. Then, in his head, he imagined the chair spinning around the world that would be frictionless”.

Analyzing the students' notes in their notebooks in the second class, it was possible to identify that Student E1B mentions the concept of friction, evidencing that this content was brought by him as a proposal for the production of the animation and accepted by his colleagues during the collaborative production. These results reveal a potential for the use of DICT from an interactive relationship and not through an individual process, as collective work has become essential in product development. According to Cohen and Lotan (2017):

> Whether or not groups are more effective than other teaching methods depends on factors such as the choice of activity, whether or not students are willing to help each other, and what motivations members have for staying engaged in the activity. (COHEN; LOTAN, 2017, p. 16).

It is important to highlight the difficulty encountered by team 2 when carrying out the transposition of concepts from Physics to their animations. Although students are able to relate the contents worked in the classroom with everyday situations, it does not mean the transposition of these situations into animation; at the same time, this limitation can help the teacher to identify conceptual flaws.

This data is in line with the results obtained by Laburú, Gouveia and Barros (2009), who used student drawings in the study of electrical circuits. According to the authors, this type of representation is a productive didactic instrument, precisely because it helps in the identification of these conceptual errors, after all, the teacher has, in addition to writing, another form of representation to evaluate learning. For Bossler and Caldeira (2013), in *stop motion* animations, students can reveal what they know and do not know about the subject worked on, especially when they fail to represent certain structures or steps in the animations. According to these authors, the production of animations represents, in terms of cognitive acquisition, more than understanding the technological processes involved in the task.

The potentialities found in the production of team 3 concern the use of animation to correct mistakes made by students, especially in relation to the representation of vectors. When describing Newton's 3rd Law verbally in class 9 and in his notebooks, it was not possible to perceive incorrect explanations; these errors only became evident when the students performed the graphical representation of the concept by the animation.

Thus, as foreseen in the interactive triangle, the DICT amplified the teacher's action in the classroom and helped in the perception of elements that were only evidenced when transposing the information to the final product. Furthermore, these data corroborate a feature highlighted by Laburú, Gouveia and Barros

(2009). For these authors, Physics is knowledge that makes use of an enormous amount of symbols, so it should be borne in mind that working with these symbols and their schemes involves, as far as the learner is concerned, cognitive activities of treatment and conversion, in addition to an effort of abstraction, causing the study to lose support in common sense and distance itself from concrete meaning.

The analysis of the video produced by team 5 helped to identify differences between the students' written explanation in the notebooks and the representation made in the animation. Thus, in addition to having the potential to detect conceptual errors made by students and help them in the learning process, *stop motion* animation challenges them to better understand the scientific process involved in the transposition performed.

These characteristics are in line with the hypotheses of this work and were evidenced in the work of Wishart (2017). Any inconsistencies present in the animations, when confronted with the phenomenon in its natural state, can be analyzed from the combined use of other modeling techniques, providing an expansion in the debate in the classroom, allowing the development of students' conceptions about nature. (RODRIGUES; LAVINO, 2019).

In general, it was possible to raise some considerations from the students in relation to the work proposal. According to their reports and notes, the main difficulty encountered in producing the animation was in relation to the technical aspects of capturing the images. According to Student E1B:

> One of the difficulties encountered by our team was the use of a tripod, because moving the table or writing on the board could interfere with the photo for animation. We had to do the animation many times (Student E1B).

Even with the difficulties presented, the student reported that “the result was cool and incredible”, demonstrating motivation in carrying out the activity, despite the adversities.

Other students highlighted the difficulty of producing a script for animation and, mainly, of transposing the concepts studied in class. Even so, they complemented saying that, after reaching the objectives of the challenge proposed by the teacher, in general the activity presented itself as a positive strategy, as reported by Student E3D: “With animation it is better to learn, because we are putting the content in practice".

Based on what was exposed in the analyses, in dialogue with the recent literature on research in Science teaching (WISHART, 2017; FERREIRA, 2016; SULLIVAN *et al.*, 2019; COHEN; LOTAN, 2017), evidence of gains in the process of teaching and learning in the class involved, both through the mediation of DICT and through the dialogicity provided by the division and disposition of students in the activities.

FINAL CONSIDERATIONS

In view of the objective outlined for this research, which intended to identify potentialities of collaborative production of animations for teaching Physics in the 9th grade of Elementary School, it can be said that this has been achieved.

With the data obtained and its respective analysis, both in relation to the theoretical framework adopted and in the dialogicity with the research literature in Science teaching, it was possible to notice that collaborative production through technological mediation can promote different possibilities for the approach of scientific concepts, bringing to the classroom a variety of everyday situations, providing students with a broad view of physical phenomena, as well as scenarios in which the student is inserted at the center of the learning process.

Thus, as established in the interactive triangle, the DICTs amplified the teacher's actions in the classroom and helped in the constructive activity of the students. In a more synthetic way, the main strengths and limitations observed in the application of the proposed didactic-methodological strategy can be listed:

- Main potentialities observed:
    - Enable the development of student creativity;
    - Collaboration among participants to overcome the proposed challenges;
    - Animations helped the researcher to identify conceptual errors;
    - As foreseen in the interactive triangle, the TDICs amplified the teacher's action in the classroom and helped in the constructive activity of the students.
- Main limitations observed:
    - Representation of vectors in animations;
    - Transposition of the contents worked in the classroom to the animation script.

Finally, it is noteworthy that the didactic-methodological strategy proposed in this research focused on the teaching and learning process of Physics concepts with 9th grade elementary school students, but the application of this strategy can help Science teachers in other areas. teaching stages, bringing the possibility of helping students to understand the contents and their relationship with everyday life, in a different way from the conventional ones.

As it is a viable didactic-methodological strategy, it is expected that this research can contribute to expand the ways of working with Physics contents in Elementary School and encourage the search for the improvement of the strategy, in addition to providing an expansion in teaching approaches centered on in the socialization of individuals.

CONTRIBUIÇÕES PARA O ENSINO DE FÍSICA NOS ANOS FINAIS DO ENSINO FUNDAMENTAL POR MEIO DA PRODUÇÃO COLABORATIVA DE ANIMAÇÕES

RESUMO

O ensino de Física nas séries finais do Ensino Fundamental constitui um desafio, tanto pela formação dos professores quanto pela mediação dos conteúdos propriamente ditos, tendo como referência a Base Nacional Comum Curricular. Este artigo tem por objetivo levantar as potencialidades despertadas nos estudantes pela produção colaborativa de animações para ensinar conceitos de Física no 9º ano do Ensino Fundamental. A pesquisa realizada é de caráter qualitativo, como um estudo de caso, e foi realizada em uma escola da Rede Municipal de Ensino de Curitiba com 23 estudantes de uma turma do 9º ano. Para isso, foi elaborada uma estratégia didático-metodológica baseada na produção colaborativa com o uso de tecnologias digitais, tendo como referência Coll, Mauri e Onrubia (2010). Foram produzidas cinco animações pelos participantes, que foram analisadas à luz do triângulo interativo proposto por Coll, Mauri e Onrubia. Os resultados obtidos demonstram que essa estratégia auxiliou na atividade construtiva dos estudantes e proporcionou uma visão mais ampla acerca dos fenômenos físicos trabalhados na sala de aula. A partir da análise textual dos resultados, considera-se que a estratégia didático-metodológica empregada nesta pesquisa pode contribuir para a abordagem dos conteúdos de Física nessa etapa de ensino, além de possibilitar que o estudante seja apresentado a esses temas de uma forma diferente das convencionais.

PALAVRAS-CHAVE: Aprendizagem colaborativa. Stop motion. Ensino de Ciências. Ensino Fundamental.

NOTES

1 Available at: http://phet.colorado.edu/pt_BR/. Access on: Sep. 23rd, 2020.

2 G.M.P. developed and applied the research methodology at the school and wrote the text of the article. N.C.S.F. participated in the development of the methodology and contributed to the writing of the article.

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