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Students' discursive interaction and argumentation during physics teaching

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ABSTRACT

This work presents some results of a study carried out in a doctorate program aiming to investigate the articulation between the discursive interaction process and the formation of arguments by students in physics classes. This is a qualitative study developed with a group of students in the 2nd grade of high school, in a public school in the State of São Paulo, in which the teacher of the class is also the researcher. The data was collected throughout a two-month period, and consisted of videoed activities and texts written by the students. The data analysis was carried out based on the concept of the Argumentative Reasoning Line (ARL), following Toulmin's (2006) argument pattern and the idea of the Reasoning Line presented by Martins and Justi (2017), along with the Mortimer and Scott tool (2002), referring to the argumentative and discursive processes, respectively. Our results revealed the use of concepts of physics in the ARL, triggered by the discursive process between the teacher-researcher and the students. Thus, we have evidence that the articulation between the discursive and argumentative process favored the students' active participation in the teaching and learning process of physics, a fact that indicates the contribution of this work to the discussions in the area of physics teaching, regarding the discursive and argumentative process use in the classroom.

KEYWORDS: Discursive process. Argumentation. Physics teaching.

INTRODUCTION

The emergence of students' argumentative discourse in the classroom as an opportunity of favoring the development of scientific knowledge competences has been investigated in the science teaching area (RAMOS; MENDONÇA; MOZZER, 2019; SASSERON; SOUZA, 2019).

According to Ramos, Mendonça and Mozzer (2019), students' participation through the elements of an argumentative cycle contributes to their learning of concepts. Sasseron and Souza (2019) pointed out that the cultural function (communication) and the psychological function (reasoning) cannot be separated. Thus, "every time we talk, we have to think about what we talk; whenever we listen, we think about what we listen to" (SASSERON; SOUZA, 2019, p. 145).

Therefore, the argumentation process in science teaching has been investigated and disseminated among researchers as one of the theme axes that favors students' active insertion in the process of investigation for scientific knowledge construction. Taking that into consideration, and seeking to contribute to the investigations on teaching and learning processes that go beyond concept exposure, we intend to broaden the study on the students' argumentation construction in high school and establish its relations with the teacher/student interaction in the discursive dynamics of the classroom.

With this purpose, we propose this investigation by questioning how the discursive and argumentative process develops in the classroom and how students apply Physics concepts in their argumentation. We defend teachers' active participation by provoking students' discursive interaction in the classroom and, therefore, engaging them in an environment that favors the construction of arguments.

Discursive activities in the science classroom have been investigated by several authors such as Mortimer and Scott (2002), who carried out a study on this theme and proposed a sociocultural tool to analyze teaching, interaction, and the production of meaning in science teaching. Five aspects are intertwined in this tool, namely, teacher's intentions, content, communicative approach, interaction patterns, and teacher's intervention.

When those authors described the topic "teacher's intentions", they presented the items underlying this theme as follows: creating a problem; exploring students' view; introducing and developing the lesson or "scientific story"; guiding students in the work with scientific ideas; supporting students in the use of scientific ideas; and keeping the narrative. As for the topic "content", those authors devised the categories description, explanation, and generalization.

In the topic "communicative approach", Mortimer and Scott (2002) explained how the teacher interacts with students in the classroom, and introduced the types of discourses as follows: dialogic, authoritative, interactive, and non-interactive. The dialogic approach defines a process in which the teacher interacts with students and allows them to express their ideas and points of view. In the authoritative approach, the teacher considers students' ideas, but only takes into consideration the scientific discourse view; therefore, only the scientific perspective is considered. The discourse is defined as interactive when more than one person takes part in it, while when only one person conducts the discourse, it is considered non-interactive.

These "interaction patterns" can be combined in four ways. The discourse is interactive / dialogic when more than one person presents several points of view. It is considered non-interactive / dialogic when only one person speaks, but several points of view are discussed. In the interactive / authoritative discourse, more than one person takes part; however, only one perspective is considered, namely, the scientific one. Finally, the non-interactive / authoritative interaction is characterized by one person's speech that presents a specific point of view only.

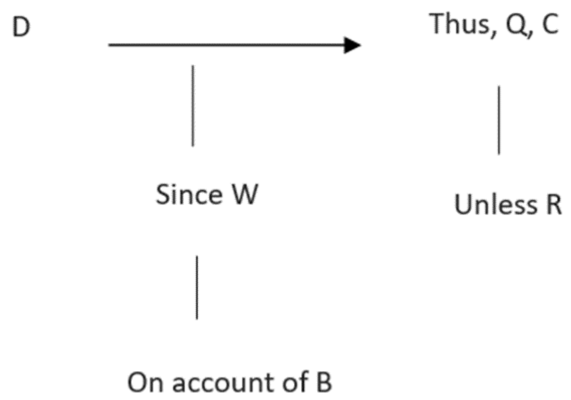
Studies on the theme "argumentation in science teaching" have shown researchers' interest in understanding the argumentative dynamics, mainly in the formal space of the classroom (*e.g.* COSTA, 2008; SÁ; KASSEBOEHMER; QUEIROZ, 2014; MARTINS; JUSTI, 2017).

Argumentation is considered an important bond between the students and their scientific education by Costa (2008). That author defends this process as a fundamental pedagogical tool, since argumentative abilities are essential for the understanding of one's own scientific development, and should be acquired through practice, contributing to the debate of socio-scientific issues by individuals.

Sá, Kasseboehmer and Queiroz (2014) explored some possibilities of this teaching tool, by applying Toulmin's argumentation scheme. With the purpose of debating this method, those authors carried out a case study with students involved in learning situations mediated by socio-scientific issues, and defended the idea that argumentative abilities enable the learners' intellectual development.

When Toulmin (2006) discussed the "layout of arguments", he presented the item "argument pattern", which included the following elements: data (D), warrant (W), conclusion (C), backing (B), qualifier (Q), and rebuttal (R). Toulmin's Argument Pattern (TAP) is shown in Figure 1.

Figure 1 – Toulmin's argument elements



Source: Toulmin (2006).

Each element is thoroughly discussed by Toulmin (2006) and distinctions are made between them. Regarding data (D) and conclusion (C), that author indicates that the former includes the "facts to which we refer as foundation for our statement", while the statement is understood as the conclusion (C), whose "merit we seek to establish".

From this intention, Toulmin (2006) explains the need to present propositions as “rules, principles, and inference licenses” to turn data into a statement or a conclusion. These propositions are called warranties (W) by that author. Figure 1 shows the relation established between the elements: “D, since W, so C”. The element “Q” or qualifier takes the function of giving quality to the conclusion (C). That author indicates some examples of adverbs that on certain occasions can be considered qualifiers such as “necessarily”, “presumably”, and “probably”.

Exception conditions, or rebuttal elements (R) indicate “circumstances in which the general authority of warranty must be put aside”, or “exceptional conditions, able to invalidate or rebut the guaranteed conclusion”. The element called backing (B) was discussed by Toulmin (2006) aiming to clarify situations regarding the questioning of why “certain warranty has to be accepted, in general, as an authoritative guarantee”. That author indicates that the warranty backing “can be expressed as categorical statements of fact”, unlike guarantees that are hypothetical statements.

Pinochet (2015) pointed out that working on the development of argumentative abilities based on the Toulmin’s scheme requires a systematized process that demands the understanding of the characteristics involved in the arguments produced by the students. That author discusses some adjustments to the structure introduced by Toulmin to make it suitable to the education context such as the work by Bravo and Jiménez-Aleixandre (2009).

Thus, Toulmin’s argument pattern has been used in several contexts, including the science teaching area, with some adjustments such as those put forward by Villani and Nascimento (2003), Motta and Motokane (2014) and Driver, Newton and Osborne (2000), who present adjustments and limitations related to the pattern elements, mainly in relation to the creation of subcategories related to the element “data” and the aspect of contextualization of individual and social interactions that occur in the argument construction situation.

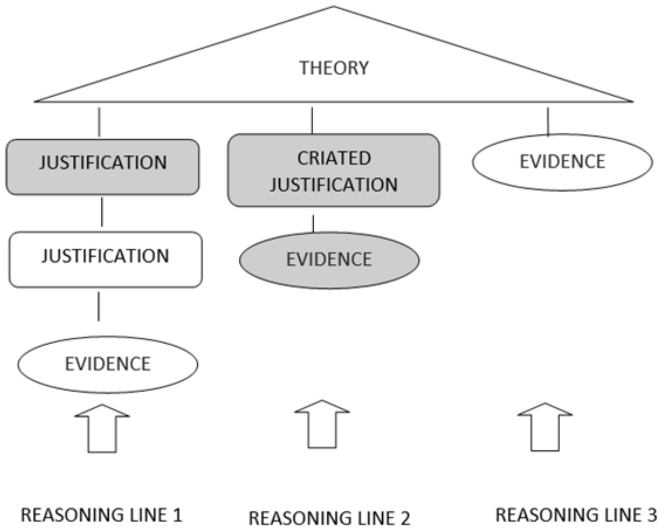
Aiming to broaden the discussions and contribute to the suitable use of the Toulmin’s argument pattern (2006), other researchers have discussed the factors that influence the argumentation process. Nascimento and Vieira (2008), for example, addressed the contributions and limits of that theory applied to argumentation situations in the light of the investigation within the education of physics teachers.

Considering the emerging discussions about the use of the argument pattern introduced by Toulmin, in this study we agree with Monteiro (2002), who stated that the structure enables the analysis of the argument construction with a view to the understanding of the logic relations between the elements. However, we think it is also necessary to understand how the discursive process between teacher and students is naturally related to the construction of the argumentation process, based on the Toulmin’s scheme (2006).

In this study, the Toulmin’s scheme was not adjusted, since it approaches the investigation of the discursive process between teacher and students in the construction of arguments using the structure presented by that author. Thus, we defend the idea that the articulation between the discursive and argumentative dynamics might favor the construction of physics concepts by the students without the need for them to understand the theory of argumentation, but rather from being a participant agent in the process. In addition, we do not emphasize the proposition of contradictory situations by the teacher, since we consider that the classroom routine not always allows such situations. Therefore, our study perspective does not consider students' intentional training, but rather their development of argumentation skills through the discursive practice in everyday situations in the classroom.

Another important aspect calling our attention was discussed by Martins and Justi (2017) and refers to the need for tools to help the understanding of the students' argumentative reasoning. Those authors pointed out how important it is to analyze "the general standards of justifications related to both the content and structure of the arguments" and proposed a methodology to evaluate controversial arguments in chemistry lessons, but they also indicated its use in other contexts based on the structure of analysis of the argumentative reasoning, which indicates reasoning lines (Figure 2).

Figure 2 – Argument structure by Martins and Justi



Source: Martins e Justi (2017).

According to those authors, the triangle represents the statement, and the gray ellipses indicate evidence given by the students, while the ellipses of white background represent evidence extracted from a text. The gray rectangles and those with white background show the justifications elaborated by the students and those extracted from a text, respectively.

In the context of this research, we carried out an articulation between the Toulmin scheme (2006) and the argumentative reasoning structure presented by Martins and Justi (2017). The argument base remains with the structure "Data-Warranty-Conclusion", while the data can be supplied by either the teacher or the students. However, to be considered a consistent argument from the physics standpoint, we indicate the need for a warranty (W) element and/or a backing (B) element based on some scientific concept. The modal qualifier (Q) and the rebuttal (R) appear as the degree of "force" that exist in the movement from the warranty (W) to the conclusion (C) (TOULMIN, 2006), in which the former qualifies, while the latter offers exception conditions.

We propose a tool to evaluate the complexity of the argument lines according to levels, in which it becomes possible to analyze whether they are supported by warranties and/or backings through physics concepts. We also described the argumentative reasoning lines (ARL) proposed for our data analysis in the item related to the methodology of this study.

We investigated both, written and oral data produced in the discussions and considered the principle that interactive actions optimize students' involvement in the teaching/learning process. We also sought answers for the question "What are the potentialities of the combination 'discursive interaction and argumentation' in the formulation of physics concepts by students?

The specific objectives of our study included to analyze the discursive process between teacher and students in the physics lesson; to analyze the ARL construction process by the students; to verify whether the discursive interaction is associated to the argumentation built up by the students, and whether it is based on physics concepts.

METHODS

This is a quali-quantitative study directed to the researcher's participation in the constitution of data in the classroom natural environment.

Within this perspective, the study was based on the analysis of the discursive process that is developed between teacher and students, focusing on the context in which the investigation occurs rather than on the results or products only (BOGDAN; BIKLEN, 1982).

As the teacher-researcher in this investigation, I involved the students in the development of a teaching sequence for the physics subject that was used in a classroom with 37 students in the 2nd grade of high school, in a public school in the state of São Paulo, in the first two-month period of the second semester in 2017.

The average age of those students was 16 years old, the group had 20 male and 17 female students, who were all familiarized with the teacher and her teaching methodology, which promoted a favorable environment for the interactions and dialogue between teacher and students. They were not explicitly trained to argument, but they had already taken part in activities with this purpose, since the teacher-researcher's teaching principle involved providing students with moments in which they could interact and actively participate in the lesson through questioning, debating, writing texts, solving problems, building up experiments, and other activities.

The choice of a theme "thermal machines" was based on the need to follow the state of São Paulo official curriculum (SÃO PAULO, 2011) for the physics subject, which is still included in that curriculum (SÃO PAULO, 2020). Taking the theme into consideration, we analyzed the students' profile and started to collect ideas and materials for the development of that proposal in the early 2017.

We started the investigation by collecting the students' initial ideas with the promotion of a discursive process in which the teacher-researcher conducted the activity using a sequence of questions presented to the students. After this phase, some demonstration activities were carried out.

At this point, data collection was carried out through activities that were videoed, texts that were written and the answers given by the students also in written form. In this report, we decided to present the results of two activities that were developed with the students in the classroom and are presented below (Chart 1).

Chart 1 – Mortimer and Scott's communicative approach categories (2002)

Activity	Description	Number of participating students	Duration and class time
1-Collection of students' initial ideas	The activity aimed to gather students' initial ideas on the theme "Thermal machines" and was divided into two parts: in the first part, students worked in groups of two or three people and answered a written questionnaire before taking part in any discursive process with the teacher. In the second part, the students took part in a discursive process with their peers and the teacher-researcher, presenting their initial ideas on the theme.	31	100 minutes in the morning class.
2-Demonstration experimental activity	The work was developed with demonstration experimental activities focusing on the themes "Heron machine" and "Steam turbine". Students took part in a discursive process with the teacher-researcher about the procedures and concepts involved in the functioning of thermal machines shown in the experiments. At the end of the activity, students produced written data expressing their ideas about the activities carried out. At this phase, the teacher-researcher mediated the discursive process by introducing the physics concepts related to the functioning of a thermal machine.	36	100 minutes in the morning class

Source: Elaborated by the authors.

These two activities were carried out in two lessons, with a 7-day interval between them. For this reason, the number of students participating in the first activity is different from that in the second activity. Thus, 31 students took part in the first activity, since 6 of them missed that lesson. In the second activity, only one student missed the lesson.

To analyze the data collected in these activities, we used the Mortimer and Scott tool (2002), referring to communicative approach lessons, that is, interactive/dialogic, interactive/authoritative, non-interactive/dialogic, and non-interactive/authoritative.

For the analysis of the argumentative process, we proposed the ARL model, which is based on the Toulmin's argument pattern and the reasoning lines introduced by Martins and Justi (2017), as presented below (Chart 2):

Chart 2 – Argumentative Reasoning Line (LRA) of strong, medium, and weak degrees and respective levels

ARL levels	**TAP elements**	**Physics concept base (YES or NO)**	**Degree**
ARL_n11	D, W, C, B, Q and R	YES	Strong
ARL_n10	D, W, C, B, Q or D, W, C, B, R	YES	Strong
ARL_n9	D, W, C, B	YES	Strong
ARL _n8	D, W, C, Q	YES	Strong
ARL_n7	D, W, C	YES	Strong
ARL _n6	D, W, C, B, Q and R	NO	Medium
ARL _n5	D, W, C, B, Q or D, W, C, B, R	NO	Medium
ARL_n4	D, W, C, B	NO	Medium
ARL _n3	D, W, C, Q	NO	Medium
ARL _n2	D, W, C	NO	Medium
ARL_n1	D, C	NO	Weak
ARL_n0	D	NO	Weak

Source: Elaborated by the authors.

Chart 2 shows each ARL classification, along with the description of the elements of Toulmin's argument pattern (2006) referring to the physics concept base, and the indication of levels and degrees of strength of each ARL.

For example, at level 11, the argumentative reasoning line (ARL_n11) is characterized as strong due to the presence of all elements of the Toulmin's scheme (2006), articulated in such a way that they support the conclusion or idea presented and are based on physics concepts, which provide warranty and backing.

Therefore, all cases presented in Chart 2 indicate the construction of an idea with argumentative reasoning, within the perspective of the Toulmin's argument pattern logic (2006). However, the ARL observation was added to analyze the argumentative process in a more complete and contextualized way regarding physics concepts.

Next, we describe some of the results of the activities carried out with the students, followed by the discussions they raised.

RESULTS AND DISCUSSION

The written answers given by the students to some questions revealed their initial ideas that were analyzed in the ARL perspective (Chart 3).

In this report, we chose to present the analysis of a question that enables a general view of the theme that was developed with the students by using a sample of data from four groups, in which the students' participation was constant in the discursive process developed through the activities. Thus, each group presents at least one student that took part actively in this interaction with the teacher-researcher.

Chart 3 – Students' initial ideas about the thermal machine concept

Students' groups	Question	Students' answers	ARL
G1: Students 1, 2, 3;	What is a thermal machine (**D**)?	*G1: Thermal machine (TM) is all technology that produces heat through energy* **(C).**	ARL_n1
G2: Students 4, 5 e 6.		*G2: TM is anything that produces heat or cold. That's why it is related to temperature* **(C).**	ARL_n1
G3: Students 7, 8;		*G3: It is a machine that uses temperature to perform its functions.* **(C).**	ARL_n1
G4: Students 10, 11 e 12.		*G4: A thermal machine can generate or retain heat* ***(C).***	ARL_n1

Source: Elaborated by the authors.

The texts produced by the students presented four argumentative reasoning lines (ARL) of weak degree at level 1. This situation is due to the fact that the students could only include their initial ideas about the theme, before taking part in an interactive process with the teacher-researcher.

After that phase, students were invited to share their initial ideas with their peers and with the teacher-researcher aiming to explore their views and work the meanings of terms that were put forward during the discursive interaction (MORTIMER; SCOTT, 2002), since the moments of teacher/students' interaction favored the appearance of the students' initial ideas and different points of view.

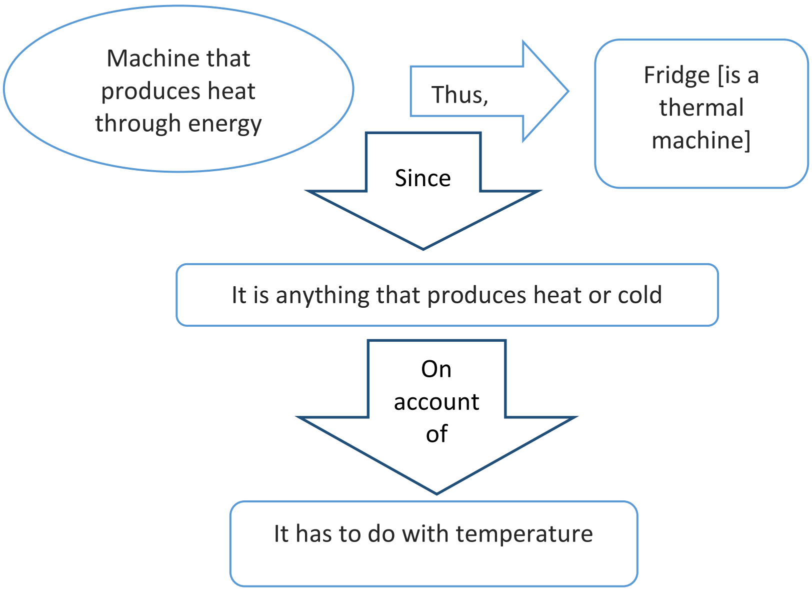
Next, we present a sample of their speech and analysis according to the Toulmin's argument pattern (2006), with the purpose of classifying the ARL type. The teacher-researcher is represented by letter T and the students by the letters Sx, where x is the number representing each student.

The excerpts below show the conversation between the teacher-researcher and her students about the thermal machine idea.

T: Today you are going to present your ideas. You should not worry about whether these ideas are right or wrong, it is important to take part. What is a thermal machine?
S1: It is a machine that produces heat through energy ***(D)***
S4: A fridge is a thermal machine ***(C)***
T: Ok, the group that mentioned the fridge, why do you think a fridge is a thermal machine?
S4: Because it is anything that produces heat or cold ***(W)****, since it has to do with temperature* ***(B)****.*

To analyze this excerpt, we created Figure 3, observing the elements in Toulmin's pattern (2006).

Figure 3 – Analysis of the episodes in the transcription of the 1st part of the discussions raised by activity 1, with a scheme of the argument structure



Source: Elaborated by the authors.

We observed the occurrence of the structure "data (D), warranty (W), backing (B), and conclusion (C)", according to the Toulmin's scheme (2006), in which the ARL was built up in collaboration by the students during the discursive process by the insertion of a piece of data (D) and the formation of a conclusion (C), supported by the warranty (W) and the backing element (B). Such structure was configurated from the students' initial ideas, since that was the moment when the theme was discussed in interaction with the teacher-researcher in an interactive-dialogic situation, but prior to the introduction of the physics concepts definition. Thus, this ARL is classified at level 4 and of a medium degree.

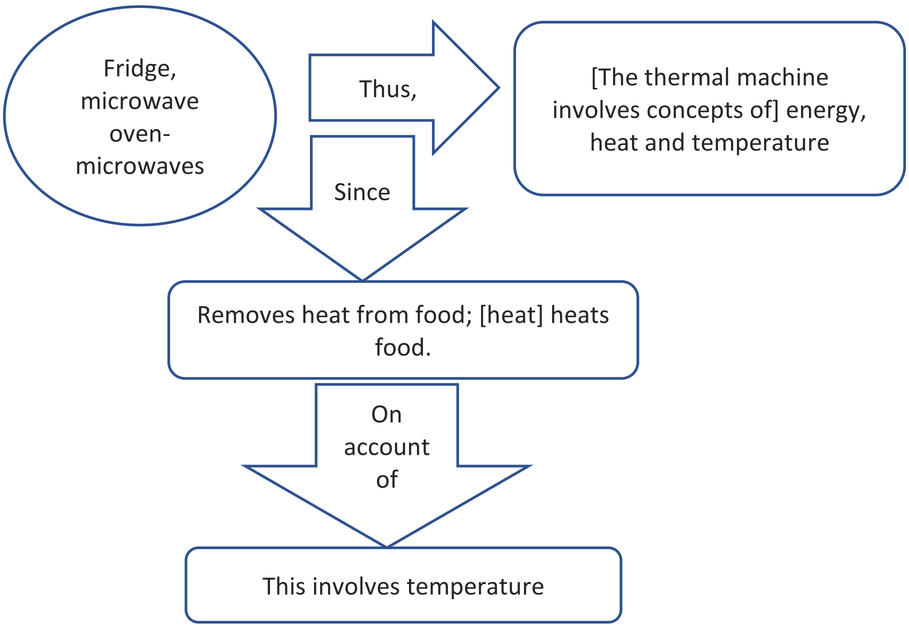
Another excerpt of the dialogue that elicited students' initial ideas, shows that the students were questioned regarding the physics concepts involved in the operation of a thermal machine, as follows:

T: How about the physics principles involved in the functioning of a thermal machine. What do think happens? For example, in the fridge (D) case, what have you imagined?
S4: The fact that it (the fridge) removes heat from the food ***(W)***
S2: That is why, energy, heat and temperature ***(C)***

> *S7: Yes. And we said that the microwave produces microwaves* ***(D)****, since it heats food* ***(W)***
> *S8: And that involves temperature* ***(B)***

In this discursive process between the teacher-researcher and students, we could observe the formation of a discourse in an interactive/dialogic situation, in which the teacher's intentions are limited to exploring the students' ideas about how a thermal machine works and the possible physics principles involved in it. According to Toulmin's (2006) pattern, an argument with the structure presented below (Figure 4) was formed.

Figure 4 – Analysis of episodes from the second excerpt of transcription of the discussions in the first activity, with the argument structure scheme



Source: Elaborated by the authors.

This analysis revealed that the ARL formed by the students is at level 4 and presents medium degree, since the students only mentioned the concepts of heat and temperature, without a deep explanation of these concepts.

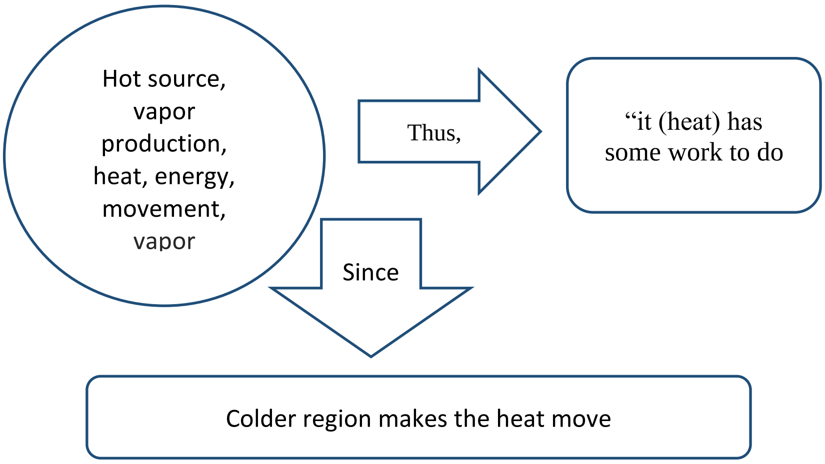
Below is the first excerpt of the transcript of the second task and respective analyses. This activity took two lessons and aimed to work on the theme "thermal machines and thermodynamics" with the students through a demonstration experimental activity called "Heron machine".

> *T: Up to the point when the temperatures are equal, that is, reach thermal equilibrium. That is why the colder air, considering this lamp, for example, is important. The heat leaves the hotter part and moves to the colder region of the system. Then, we can identify two important parts in the system. Which source is the lamp?*
> *S11: The hot one* ***(D)***
> *T: And we need a cold source, so that the heat flow can occur. Does the machine produce anything?*
> *S13: Produces vapor* ***(D)***
> *T: And what does the vapor produce?*
> *Students: Movement* ***(D)***

T: And due to this movement, in physics we say that some work is carried out. Now, let's organize the ideas formed about the thermal machine. What does the thermal machine need to work?
Students: Heat
S7: Energy ***(D)***
T: And what is needed for the heat to flow?
S1: A colder region so that the heat moves there ***(W)***
T: And from this heat, what must occur?
S10: [Well] It has to accomplish some work ***(C)***

Figure 5 represents our analysis of this excerpt in the light of Toulmin's scheme (2006).

Figure 5 – Analysis of episodes of the 1st excerpt of the transcription of the second activity and the argument structure scheme



Source: Elaborated by the authors.

Considering the ARL pattern previously proposed, we classified this ARL as strong and at level 7 (ARL_n7), since we could notice the presence of a basic structure "Data – warranty – conclusion" in which the warranty presented is related to the physics concept of heat movement due to the existence of a cold region, which is the fact that provokes the work to occur. Thus the "D-W-C" structure is based on physics knowledge.

Therefore, some important concepts related to a thermal machine were discussed, in an interactive/authoritative manner, since these concepts were elicited from the students until they got a specific point of view regarding the definition of a thermal machine.

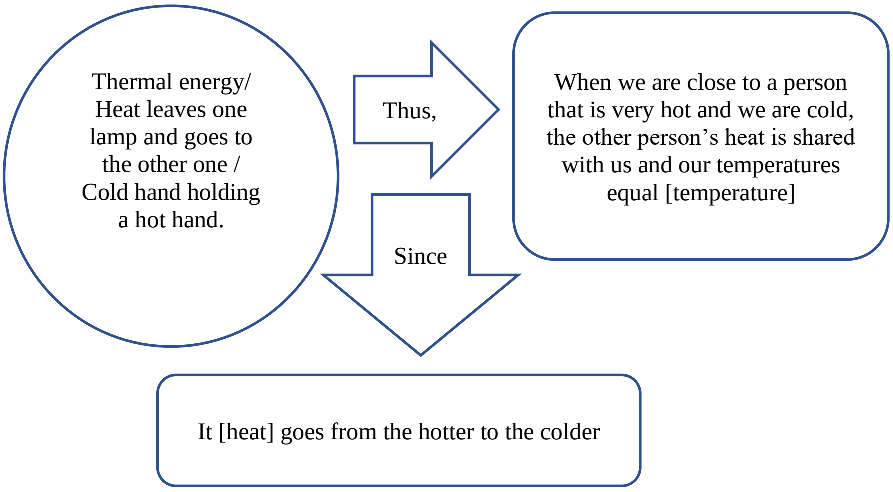
In the second excerpt of the same discourse, we observed that the teacher-researcher promoted an intervention by checking the students' understanding, as follows:

T: Now, let's resume the idea of heat, or thermal energy ***(D)****. [previously introduced by students 1 and 8]. Where does it come from?*
Students: From the lam [heat coming from the lamp] ***(D)***
T: This is the heat source, or the hot source. And where is this heat flowing to?
S7: To the water, to the lamp ***(D)***
T: Look, this heat, this energy, where does it go to?

S7: It is a conduction
T: Where is this energy conducted to?
S1: It goes from the hotter to the colder ***(W)***
S13: Yes, like when your hand is cold and you hold a hotter hand ***(D)***
S4: When you are close to somebody that is very hot and you are cold, the heat from the other person is shared with you and the temperatures of both bodies equal ***(C).***

Figure 6 shows the analysis of this excerpt following Toulmin's pattern (2006).

Figure 6 – Analysis of episodes from the second excerpt of the transcriptions of the second activity and argument structure scheme



Source: Elaborated by the authors.

Students introduced data and got to a conclusion about the idea of heat as a kind of energy that is transferred from one body to the other, due to a difference in temperature (hot and cold), forming an ARL that was strong and at level 7.

After the discursive process developed by the teacher-researcher and her students, they wrote a short text, in which they reported their considerations about the concepts worked during the lesson. Below are some of the texts produced by the groups of students that had good participation in the activity.

Chart 4 – Textos escritos pelos alunos acerca de uma máquina a vapor

Students' groups	**Task: Elaborate an explanation based on physics concepts about the functioning of a vapor machine.**	**ARL**
Group 1: S 1, S2, and S3	*The container with fire* ***(D)*** *passes heat to the container with water* **(W)** *through convection* (**B**)*, thus, the water boils and the vapor generated creates this spinning movement* **(C)***, if that is the case* [probably] *it generates energy* **(Q).**	ARL_n10
G2: Students 4, 5, and 6	*When the fuel burns* **(D)***, it transforms liquid in vapor* **(W)** *and thus produces some work (movement)****(C).***	ARL_n7

Group 3: S7 and S8	*A vapor machine has an oven where coal, oil, wood, or any other fuel is burnt to produce heat energy and carry out some work* **(D)**. *The heat produced by the fuel burnt turns the water into vapor inside the boiler* (**W**). *The vapor expands and occupies a space many times larger than that occupied by the water* **(B)**, *and so it is used to activate a turbine that* [certainly] *generates work* **(Q)**.	ARL_n10
Group 4: S10, S11, and S12	*All thermal machines* **(D)** *work based on the principle that heat is a kind of energy* **(W)**, *that is, it can be used to carry out some work* **(C)** *and its functioning obeys thermodynamics laws* ***(B).*** *When considering the vapor machine, the work is carried out by the highly pressured water and the high temperature* ***(Q)***.	ARL_n10

Source: Elaborated by the authors.

Our results (Chart 4) demonstrate that an ARL of strong degree and at levels 7 and 10 emerged.

When analyzing the ARL presented during the discursive process occurred in the first and second activities, ARL at levels 4 and 7 emerged, respectively. Thus, there was an improvement in the ARL presented by the students.

Regarding the data extracted from the texts written by the students, Table 1 shows a comparison between the ARL levels emerging before and after the discursive process developed throughout the two activities.

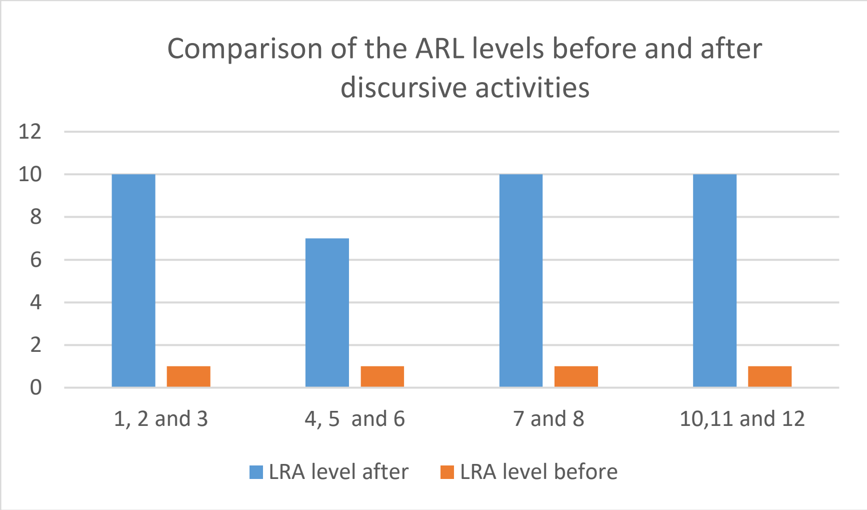
Table 1 – Comparison of ARL before and after the discursive process carried out during the activities

Students	ARL before the activities	ARL after the activities
1, 2 and 3	ARL_n1	ARL_n10
4, 5 and 6	ARL_n1	ARL_n7
7, 8	ARL_n1	ARL_n10
10, 11 and 12	ARL_n1	ARL_n10

Source: Elaborated by the authors.

These results also evidence the improvement of the quality of the ARL in the students' written texts (Figure 7):

Figure 7 – ARL level before and after the discursive activities



Source: Elaborated by the authors.

We could observe that these four groups of students developed their texts in a productive way, including a theoretical framework based on physics concepts that were developed during the discursive process between the teacher-researcher and her students.

CONSIDERATIONS

Our results evidenced the students' participation during the discursive process with the teacher-researcher. In the elicitation of the students' initial ideas, they participated actively and presented ideas related to the concepts of heat and temperature. However, without any definition of those concepts.

The students initially wrote their ideas and then were invited to interact with the teacher-researcher and their peers in the classroom. We noticed that the students' written reports at this point showed a low level of quality and did not present any physics concepts, since they had neither received any instruction nor taken part in any discussion about the theme. Therefore, data was collected and initial conclusions were formed that were very relevant for the development of the next activity, in which the students could share their ideas through a discursive process with the teacher-researcher. That discourse was predominantly developed following the communicative approach with an interactive/dialogic dimension, in which teacher and students explored ideas, asked authentic questions, and explored different points of view (MORTIMER; SCOTT, 2002). The discursive process that occurred when students shared their ideas, resulted in an improvement of the level of the ARL presented by the students, since the questionnaire resulted in a level 1 ARL, but during the discursive process the students were able to produce a level 4 ARL.

In the second activity, in general, the discursive process was characterized in the dialogic/authoritative pattern, in which "the teacher usually leads students through a sequence of questions and answers aiming to reach a specific point of view" (MORTIMER; SCOTT, 2002). Our results showed that a strong ARL emerged from the arguments formed during the discursive process and in the students' written arguments, since they were founded on physics concepts related to processes such as convection, water boiling point, vapor expansion, heat as a source of energy, and referred to thermodynamics laws, water molecule movement, and transformation into vapor as a result of high pressure. Thus, this improvement of the ARL degree in the oral discussions and students' written texts seems to have resulted from the teacher-researcher's intervention during the discursive process. This fact evidences the relevance of the discursive interaction process in the formation of arguments by the students.

By joining Toulmin's scheme (2006) and the reasoning lines by Martins and Justi (2017) we were able to analyze the arguments put forward by individual students or the group of students in a more complete and efficient way. This combination enabled the analysis of all possibilities when observing the Toulmin's argument pattern in connection to the context where the ideas appeared.

Therefore, we found evidence that the combination of "discursive interaction and argumentation" is articulated with the formation of physics concepts, since we observed the emergence of ARL at good quality levels during the oral discussions and in the written texts, that is, arguments in which warranty (W) and/or backing (B) were founded on physics concepts.

In general, the use of activities focusing on discursive interactions and argumentation might be a viable methodology to be used in several contexts, even as an option for the teaching/learning process to occur in remote classes. However, such methodology depends on the creation of conditions and/or tools that provide teacher and students with a suitable environment so that these interactions can be developed.

INTERAÇÃO DISCURSIVA E ARGUMENTAÇÃO DOS ALUNOS NO ENSINO DE FÍSICA

RESUMO

Este trabalho traz alguns resultados acerca de uma pesquisa de doutorado com o objetivo de investigar a articulação entre o processo de interação discursiva e a formação de argumentos pelos alunos no Ensino de Física. Desenvolvemos o estudo, de cunho qualitativo, com uma turma de alunos da 2ª série do Ensino Médio, em uma escola pública do Estado de São Paulo, na qual a professora da turma é também a pesquisadora. Os dados foram constituídos durante um bimestre, por meio da filmagem das atividades e pela escrita de textos pelos alunos. Para a análise dos dados propomos o conceito de Linha de Raciocínio Argumentativo (LRA), com base no padrão de argumento de Toulmin (2006) e a ideia de Linha de Raciocínio apresentada por Martins e Justi (2017), juntamente com a ferramenta de Mortimer e Scott (2002), referentes aos processos argumentativo e discursivo, respectivamente. Os resultados evidenciaram o uso de conceitos de Física nas LRA, desencadeadas por meio do processo discursivo entre a professora-pesquisadora e os estudantes. Assim, temos indícios que a articulação entre o processo discursivo e argumentativo favoreceu a participação ativa dos alunos no processo de ensino e de aprendizagem de Física, fato que indica a contribuição deste trabalho para as discussões na área do Ensino de Física, referentes ao uso do processo discursivo e argumentativo em sala de aula.

PALAVRAS-CHAVE: Processo discursivo. Argumentação. Ensino de Física.

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