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Learning Configurations and Teaching Knowledge

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ABSTRACT – Learning Configurations and Teaching Knowledge. This paper presents the results of a study carried out with students from a public school in the state of Goiás. We involved the students in situations of research/experimentation, interviewed the teacher about his planning and analyzed the reports of his practice according to the Strands of Science Learning (SSL). It was evidenced that engaging in scientific reasoning prevailed in the teacher's planning and practice. Engaging in scientific practice, which presented a high intensity in planning, was reduced during teaching. During classes, learning of science knowledge was enhanced. Therefore the SSL help understand and characterize teaching practice and student learning in learning configurations based on the experimentation process.
Keywords: **Strands of Science Learning. Teaching Knowledge. Learning Configuration. Teacher Practice.**

RESUMO – Configurações de Aprendizagem e Saberes Docentes. Este artigo apresenta resultados de uma pesquisa realizada com estudantes de uma instituição pública de Goiás. Envolvemos os alunos em situações de investigação/experimentação, entrevistamos o docente sobre seu planejamento e caracterizamos os relatos sobre sua atuação à luz dos Focos da Aprendizagem Científica (FAC). Evidenciou-se que, no planejamento e na atuação do professor, predominou o envolvimento com raciocínio científico. O envolvimento com a prática científica, que apresentou elevada intensidade no planejamento, reduziu durante a atuação docente. Durante as aulas, intensificou-se a aprendizagem do conhecimento científico. Os FAC, portanto, ajudam a compreender e caracterizar a atuação docente e a aprendizagem dos discentes em configurações de aprendizagem pautadas no processo de experimentação.
Palavras-chave: **Focos da Aprendizagem Científica. Saberes Docentes. Configurações de Aprendizagem. Ação Docente.**

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Introduction

In the last ten years, we have sought in our research to relate the themes of relationship with knowledge (Charlot, 2000) and teaching knowledge (Tardif, 2002), thus drawing some consequences for the teaching of science and mathematics and education in general (Arruda; Lima; Passos, 2011; Arruda; Passos, 2015). The link between those two authors emerged from the following phrase by Tardif (2002, p. 36):

> [. . .] the relationship of teachers with knowledge is not limited to a function of transmitting ready-made knowledge. Its practice comprises different kinds of knowledge with which teachers have different relationships. One may define teaching knowledge as multiple knowledge, composed of the more or less coherent combination of knowledge derived from professional training and knowledge of subjects, curriculum and experience.

The reference to relationship with knowledge made by Tardif (2002), albeit with a different meaning, took us to Charlot (2000), where relationship with knowledge is essentially defined as a form of relationship with the world, in which the subject inserts himself with his desires, idiosyncrasies, which define the uniqueness of this relationship. In the author's view, "[. . .] relationship with knowledge is the subject's relationship with the world, with himself and with others. It is relationship with the world as a set of meanings, but also as a space of activities, and it is inscribed in time" (Charlot, 2000, p. 78).

Given that relationship with knowledge is relationship with the world, we may think of various spaces and places conducive to the circulation of knowledge, that is, we may think of such relationships for situations of education and of formal, informal and non-formal learning. Considering the classroom in particular, we are talking about school knowledge. This relationship then becomes the subject's relationship with the school world, with all the specificities of that locus.

For this particular setting, we can define three dimensions of relationship with knowledge, as shown in Chart 1:

Chart 1 – Dimensions of Relationship with Knowledge

A. *Epistemic relationship* with knowledge: This relates to relationship with knowledge as an object of the world to be appropriated and understood; knowledge endowed with independent objectivity, consistency and structure; knowledge "existing in itself" placed in "objects, places and people" and immersed in a "world of knowledge distinct from the world of action, perceptions and emotions" (Charlot, 2000, p. 69).
/
B. *Personal relationship* with knowledge: This refers to the "relationship of identity with knowledge"; knowledge as an object that makes sense, which is part of the subject's personal story, life and expectations (Charlot, 2000, p. 72); knowledge as an object of desire, of interest; knowledge that the subject *likes* and is driven to search for.
/
C. *Social relationship* with knowledge: This relates to the fact that the subject is born within a social space, occupying an objective social position that defines the initial context in which he will establish a relationship with knowledge; in this environment, knowledge has values ascribed by the community in which the subject lives, receiving the impact of the expectations and aspirations of others regarding him (Charlot, 2000, p. 73).

Source: Adapted from Arruda, Lima and Passos (2011).

The concerns stemming from the theoretical reflections mentioned above motivated us to carry out the investigation presented below. To this end, we conducted an interview with a technical education teacher and later observed his classes over six months. Details of data collection and methodology shall be discussed in a specific section of this paper. Discussion and analysis of data is delimited by the planning and development of classes based on situations of investigation/experimentation. The goal of this investigation, whose results are herein presented, is to develop a characterization of teaching concepts and practices, including within this scope students' learning in light of Strands of Science Learning (SSL) established as a priori categories. It should be noted that this research is part of a larger project studying relationships with knowledge in the classroom.

We sought to outline the abovementioned characterization from the incidence of units of meaning in the categories of analysis. Besides this analytical procedure, we made a qualitative description of the categories with lowest incidence. Following this brief introduction, we proceed to the presentation of the theoretical frameworks on which our interpretation process is grounded.

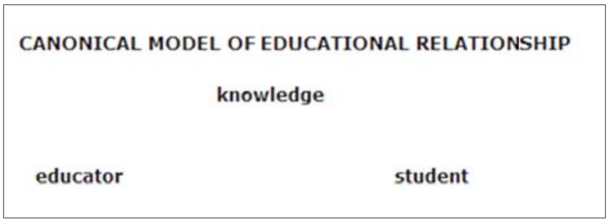
Didactic-Pedagogic Triangle

The best-known classroom model is the triangular model, whose origins date back to the ancient Greeks. In ancient Greece, the core of educational relationships was communication between masters and apprentices. After Socrates, this emphasis on discussion shifted to dialogue between educator and student, becoming a relationship between them and objective and universal knowledge, which is independent of the subject. As Gauthier and Tardif point out (2013, p. 41):

> The teacher does not speak in his own name, but in the name of knowledge that is independent of his subjectivity and of which he is the competent representative before the student.

Figure 1 illustrates this model, which Gauthier and Tardif (2013) call Canonical Model.

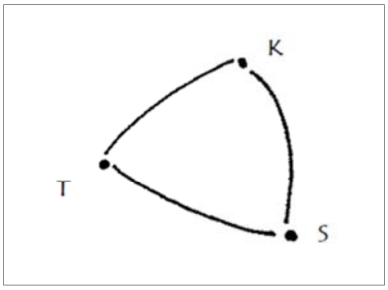
Figure 1 – Canonical Model



Source: Gauthier and Tardif (2013, p. 43).

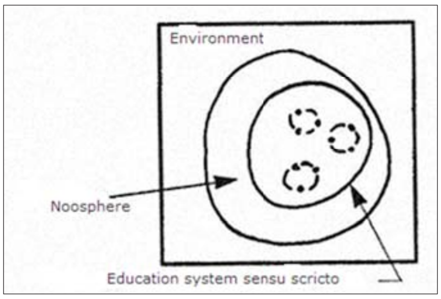
This same triangular relationship is called by Chevallard (2005) Didactic System, a basic unit of analysis used by him to develop his ideas on didactic transposition. A set of didactic systems is called Education System, which is immersed in the social environment. Between the education system and society there is what the author calls noosphere, that is, an intermediate layer responsible for defining how the education system, and consequently the didactic systems (classrooms), should function. These representations are illustrated in Figures 2 e 3:

Figure 2 – Didactic System



Source: Chevallard (2005, p. 26).

Figure 3 – Education System



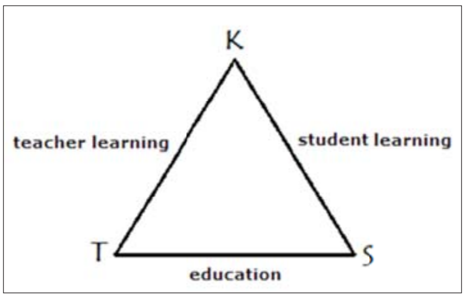
Source: Chevallard (2005, p. 28).

The triangle in Figure 2 may be interpreted as a triangle of relationships with knowledge involving teacher (T), students (S) and knowledge or content (K) and represents the classroom. This triangle has been used by various authors (Gauthier et al., 2006; Houssaye, 2007; Arruda; Lima; Passos, 2011). For Gauthier et al. (2006, p. 172) it may be called “didactic triangle” or “pedagogic triangle”. What differs from one author to another is the way the edges of the triangle are interpreted. For us, the edges T-K, T-S and S-K can be interpreted as follows:

- T-S indicates the relationships that teacher T establishes directly with class S, or with a specific student, and represents the *teaching* he practices according to his own perceptions.
- S-K indicates the relationships that class S, or a specific student, establishes with knowledge K as subject, content, concept, etc., and represents *student learning* as perceived by the teacher.
- T-K indicates the relationships that teacher T establishes with knowledge S as subject, content, concept, etc., that is, it represents *teacher learning*[1] as perceived and/or practiced by the teacher.

Therefore, the triangle in Figure 2, which we call the “didactic-pedagogic triangle”, can be represented by Figure 4:

Figure 4 – Didactic-Pedagogic Triangle



Source: Authors.

Relationships with Knowledge in the Classroom

Gauthier and Tardif (2013) stress that teaching practice in the classroom is conditioned by two factors: content management and class management (Tardif, 2002; Gauthier et al., 2006). Content management is defined by Gauthier et al. (2006, p. 197) as "... the set of operations the teacher draws on to enable students to learn the content," that is, it refers to the activities and strategies the teacher uses so that the goals proposed in his planning result in students' learning of concepts. Class management "... consists of a set of rules and arrangements necessary to create and maintain an orderly environment conducive to both teaching and learning" (Gauthier et al., 2006, p. 240), i.e., it is the management of order in the classroom, the development of rules, routines and procedures to create an atmosphere favorable to educational activity. We believe that viewing the teacher's tasks according to this duality has a limitation:

> In our view, considering the essential tasks of teachers in the classroom to consist only of content management and class management has at least one limitation: it seems to us that the task of managing themselves, their learning, their identity, their desires, their involvement should also be included among the tasks that structure the classroom practice of teachers (Arruda; Passos, 2015, p. 07).

One solution to this problem stemmed from an expanded view of the didactic-pedagogic triangle, incorporating the ideas of epistemic, personal and social relationships with knowledge previously presented in Chart 1. In this sense, the teacher's tasks are related to managing the relationships of the edges of the didactic-pedagogic triangle, explained in Chart 2.

Chart 2 – Management of Relationships in the Classroom

Management of T-K edge: management of the teacher's relationships with content./
Management of T-S edge: management of the teacher's relationships with teaching./
Management of S-K edge: management of the teacher's relationships with learning.

Source: Adapted from Arruda and Passos (2015).

This approach has the following advantages over the twofold structure of teachers' tasks proposed by Gauthier and Tardif (2013):

> ... it is not about managing objects (knowledge and class), but managing relationships (epistemic, personal and social); moreover, the teachers' task of managing themselves as developing professionals is included in the conditioning factors (Arruda; Passos, 2015, p. 07).

Strands of Science Learning and Learning Configurations

In a report by the National Research Council (2009, p. 42), science learning in informal environments is conceived as a set of six dimensions which intertwine like strands of a rope “. . . to produce experiences, environments and social interactions” attracting “. . . people of all ages and backgrounds toward greater scientific understanding, fluency and expertise” (Arruda et al., 2013, p. 07). These strands are presented in Chart 3:

Chart 3 – Strands of Science Learning (SSL)

Strand 1: *Developing interest in science*. This refers to motivation, emotional involvement, curiosity, willingness to persevere in learning science and natural phenomena, which can affect the choice of a scientific career and lead to lifelong science learning.
Strand 2: *Understanding science knowledge*. This addresses learning the main concepts, explanations, arguments, models, theories and scientific facts that frame Western civilization’s understanding of the natural world.
Strand 3: *Engaging in scientific reasoning*. Asking and answering questions and evaluating evidence are core activities in doing science and *navigating* successfully through life. The generation and explanation of evidence are key to scientific practice; scientists are constantly redefining theories and building new models based on observation and experimental data.
Strand 4: *Reflecting on science*. This focuses on learning science as a way of knowing and as a social enterprise. It includes an appreciation of how the thinking of scientists and scientific communities evolves over time as well as reflection on one’s own learning.
Strand 5: *Engaging in scientific practice*. This focuses on how learners in informal environments can appreciate the way scientists communicate in the context of their work as well as learn how to master scientific language, tools and norms as they participate in science-related investigation.
Strand 6: *Identifying with scientific enterprise*. This focuses on how learners view themselves with respect to science, or how people develop their identity as science learners or even as scientists. It is relevant to a small number of people who, in the course of their lives, come to see themselves as scientists, but also to most people who will not become scientists.

Source: Arruda et al. (2013, p. 08).

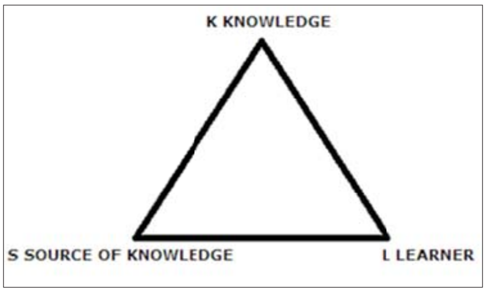
An important aspect of these strands is that they are interconnected in such a way that progress in one of them contributes to the development of others (Fenichel; Schweingruber, 2010, p. 02-05).

This overview of SSF is followed by an explanation about learning configurations resulting from the study of the relationships in the didactic-pedagogic triangle. The definition of learning configuration is as follows:

> In our research group we have used the term learning configurations to describe all physical and virtual learning possibilities and environments, be they formal, informal or non-formal. This term we adopted expands the meaning of the word *venue* used in the National Research Council – NRC (2009, p. 11).

Learning configurations follow a similar framework as that of the didactic-pedagogic triangle, as seen in Figure 5.

Figure 5 – Learning Configurations



Source: Arruda and Passos (2015, p. 11).

The core ideas that underlie the concept of learning configurations adopted in this paper are described below:

a) Learner L represents the subject who learns. He is the *locus* where learning happens. No one can learn for him. We are therefore in search of the epistemic, personal and social relationships that L establishes with his learning: whether he learns or not; whether he wants to learn or not; whether he values learning or not; or even how he learns, why he learns, with whom he learns, etc.

b) Knowledge K is understood as defined in Charlot (2000, p. 61), that is, it shares the subjectivity of knowledge but also the objectivity of information, and can thus be transmitted.

c) Source of knowledge S may be a person or a group of people (a teacher, a monitor, a student, a community); a real object (a book, a magazine, a newspaper); a mental object or sensory impression (an idea, an image, a sound); a digital platform (a website, a social network); an activity, an interpersonal relationship, etc. The source is independent of the subject who learns and can be objective or subjective (Arruda; Passos, 2015, p. 11).

We argue that a learning configuration can be *induced* by one or more of the strands of science learning (SSL) described above. Thus, the *inducing* strand of the configuration determines its predominant traits, but the traits of the other strands are also present. In other words, to characterize a learning configuration we look for incidences of the units of meaning associated with a given SSL and the distribution of the intensities of each strand that characterizes such a configuration.

In the study, whose data and outcomes feature herein, the guiding strand is strand 3 (engaging in scientific reasoning), a dimension that encompasses activities involving research/experimentation.

Given the above, the following investigative questions were raised: How does knowledge circulate in classes centered on research/experimentation situations? How do the planning and execution of classes centered on engagement in scientific reasoning contribute to student learning? How is this reflected in teaching practice and student learning in the classroom?

In search of answers to these questions we employed the procedures described below.

Methodological procedures

This research is a qualitative study, whose main features, according to Flick (2009), are the correct choice of appropriate methods and theories; the recognition and analysis of different perspectives; the researchers' reflections on their research as part of the process of knowledge production; and the variety of approaches and methods. Other aspects pointed out by the author are: the appropriateness of methods and theories; the perspectives of the participants and their diversity; and the reflexivity of the researcher and research. In his words:

> Qualitative research is not based on a unified theoretical and methodological concept. Various theoretical approaches and their methods characterize the discussions and the research practice. Subjective viewpoints are a first starting point. A second approach studies the elaboration and course of interactions, while a third seeks to reconstruct the structures of the social field and the latent meaning of practices (Flick, 2009, p. 08).

Among the various approaches to qualitative research, we understand that Discursive Textual Analysis (DTA) is the one that can best provide answers to our research questions, since it allows a broad understanding of the phenomenon in question. According to Moraes and Galiazzi (2011), discursive textual analysis is a cycle comprising the following steps: break-up of texts; relationship-building; apprehension of new meanings. These steps can be seen as an analytical movement of self-organization that enables the production of new understanding of the phenomena being studied.

According to Moraes and Galiazzi (2011), break-up followed by unitization is the stage in which the texts that make up the *corpus*[2] of analysis are fragmented into elemental units that are the *quantum* of analysis. Before proceeding with text deconstruction the researcher must be immersed in the *corpus* to broadly understand the data under analysis without losing sight of the relation between part and whole, which occurs when the break-up is taken to extremes.

To help in this process, it is important to create a coding system for these units so one can return to the original text whenever necessary. In this paper, as we worked with statements by a teacher and students, the teacher will be identified as T and the students – a total of twenty-six – by S1, S2 through S26. The interpreted fragments were identified as E (for excerpt) and follow a continuous numbering, E1, E2, E3 and so on.

The strands of science learning – strand 1, strand 2, strand 3, strand 4, strand 5, strand 6 – were taken as a priori categories. The investigation was carried out in a technical education classroom of a public institution in the state of Goiás with a physics teacher and his twenty-six students.

We initially conducted an interview with the teacher in which he provided information about the course planning. An audio recording was made of this interview, which was later transcribed. Using this transcription we proceeded to break up the texts, aiming to identify units of meaning related to the characterization of the lesson planning. By establishing such units, we identified the corresponding SSL and thus developed a profile that could characterize the lesson planning. These elements helped us answer the first question previously described: How does knowledge circulate in classes centered on research/experimentation situations?

We then proceeded to transcribe the filmed classes, which, after being interpreted and organized according to the categories assumed a priori, allowed us to characterize the teacher's interventions and obtain evidence of student learning, which helped answer the other two guiding questions of this investigation: How do the planning and execution of classes centered on engagement in scientific reasoning contribute to student learning? How is this reflected in teaching practice and student learning in the classroom?

Data Presentation and Analysis

In the search for the inducting strand capable of characterizing a systematized class, according to research/experimentation situations for the teacher that was part of our research, we interpreted and adjusted the interview data that focused on class planning. With this process, we came to the conclusion that the main strand for this phenomenon was strand 3 – engaging in scientific reasoning.

Chart 4 features elements of these analytical procedures such the excerpt number, the units of meaning (teacher reports) and the strand to which those units were allocated. Only a few examples of units of meaning are featured, since presenting the entire interview would take up too much space.

Chart 4 – Examples of Units of Meaning for Teacher Planning

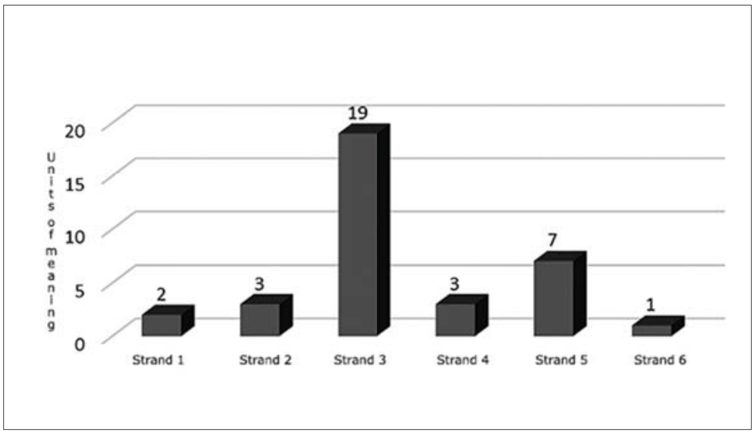
EXCERPTS	UNITS OF MEANING	STRANDS
3	T: Although I have an undergraduate teaching degree, the graduate degree in education went much deeper... the difference in my training is noticeable, especially for teaching high school.	5
4	T: I mainly learned that the students' rhythm is different from yours. Now I encourage students to question . . . When I give the answer to an exercise I ask: Is this consistent, it is coherent . . .? It is important to stir students' scientific side, their autonomy . . . Students must learn to learn independently.	3

13	T: I've never strayed from the traditional curriculum. Mechanics in year 1, thermology, optics in year 2. I don't intend to . . . plan a different course, only different lessons. It's a long process.	2
16	T: I think that, ideally, each group of teachers from that campus should build their own materials. That would make it easier to use such materials for group work.	5
27	T: I imagined working in engineering, maybe environment, but I ended up discovering a vocation for teaching.	6
31	T: Nowadays I try, and I know it's going to be a long process, to put students to work. Maybe, when teaching about inertia, if teachers gave this example of the key first and then discussed, it might be better.	3
32	T: The teacher exits the stage and places students at the center. We propose an activity close to students' daily life, for example, travelling by car, bus, canoe . . . It will depend on their social and cultural background. The theory I follow attaches great importance to social and cultural contexts and to discussing concepts.	3

Source: The authors.

Graph 1 features all thirty-five interview excerpts classified in each of the six strands.

Graph 1 – Characterization of teacher planning according to SSL



Source: The authors.

The graph clearly shows the predominance of strand 3 (engaging in scientific reasoning), followed by strand 5 (engaging in scientific practice), with seven excerpts. The other four strands were not represented in any significant way.

The high frequency of strand 3 expresses the teacher's understanding of the importance of teaching situations structured by research/experimentation activities for student learning. This is clearly stated in the following excerpt:

> I mainly learned that the students' rhythm is different from yours. Now I encourage students to question . . . When I give the answer to an exercise I ask: Is this consistent, it is coherent . . .? It is important to stir students' scientific side, their autonomy . . . Students must learn to learn independently (T, E4).[3]

Strand 5 (engaging in scientific practice) expresses the teacher's concern to include students in group activities, which also relates to strand 3 (engaging in scientific reasoning). The following comment reveals the teacher's involvement in this sense:

> I think that, ideally, each group of teachers from that campus should build their own materials. That would make it easier to use such materials for group work (T, E16).

As previously mentioned, after analyzing the teacher's interview, we started observing his classes. The chart below features some examples from a total of one hundred and nine excerpts that occurred in those classes, following the structure of Chart 4: excerpt number, then the dialogues of those excerpts and lastly the strand to which they were allocated. Chart 5 represents the teacher's relationship with knowledge and his relationship management. In other words, his discursive interactions express his relationships with teaching and student learning and may be related to the T-S and S-K edges discussed in Figure 4.

As in the previous example, only a few examples were included in Table 5, since presenting all 109 excerpts would be exhausting. However, Graph 2 features all excerpts according to the respective strands.

Chart 5 – Units of Meaning and Relationship with Strands in Teaching Practice

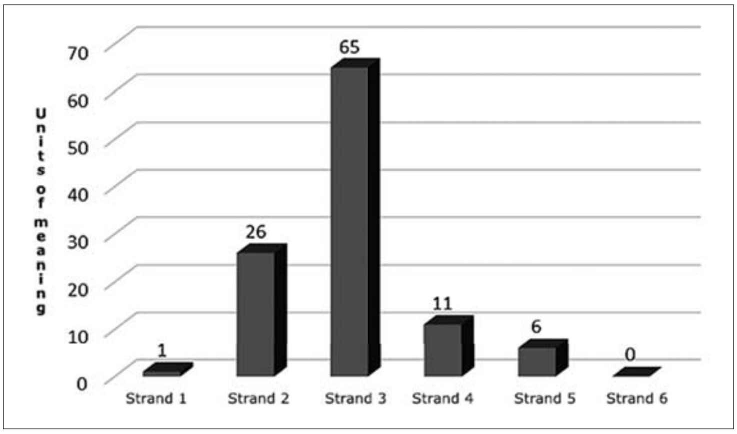
EXCERPTS	UNITS OF MEANING	STRANDS
5	T: Why is a single measurement system important? Why is it important to use the "meter" worldwide? S2: Rules . . . S3: Laws, programs . . . T: Is SI a system? S1: Yes.	3
23	T: What do you have to do for this number to be lower than 10? You have to move the decimal point. S9: Then multiply by 10^4. T: But where will the point be? S9: Between 3 and 9, right? T: That's it!	3

24	T: There are 4 experiments, if you want to start with this one, which takes longer. I'll send the instructions via the WhatsApp group. Sit around that table, please. I've sent you the lesson guide. This is activity 3. Groups of 8 at most. Let's split into 4 groups. This is activity 1. Who wants to do it? S8: We will!	3
56	T: What's the mass measurement unit in SI? S1: Kg! T: Is it kilo, class? Is kilo correct? S1: No! T: The prefix kilo means 1000. When you say kilo, you actually mean kg. But if you only say kilo, you are referring to a number, a value.	2
76	S8: So in this case will it always be four numbers at most? T: No, it can be any amount.	2
89	T: 94.2 cubic meters, class. When you multiply by 1000, you get liters. So 94.2 cubic meters is the same as 94200 liters. Each truck carries 9420 liters. If I divide the volume of the tank by the volume of each truck, I'll know how many trips it must make.	2
68	T: Let's measure the 300 ml one, ok? Let's confirm it. This is useful for when you go to a soccer match. The vendor shouts: "300 mL plastic cups."	5
90	T: Look here, class. Finding the length of the 16-roll pack. 16 rolls of 30 meters each, right? S6: That's 480. T: 480 meters. So a 16-roll pack is 480 meters long. And the other one? S6: 30 by 12. S1: That's 300 meters. T: It's not 300 . . . S2: 600. 50 by 12. T: Now we have to find the price per meter. S6: It's 1.12. T: What's the price of the 16-roll pack? S1: 19.20. T: So it's 19.20 divided by 480, because you want the price per meter. S12: It's 0.04. T: That's 4 cents. The other roll is 3 cents. S1: It's better to buy the 16-meter then.	3

Source: The authors.

All one hundred and nine excerpts collected during the class recordings were classified according to the six strands. The breakdown is featured in Graph 2.

Graph 2 – Characterization of teaching practice according to SSL



Source: The authors.

From the analysis of Graph 2 we can infer that the reduced incidence of strand 5 (engaging in science practice) and the increase of strand 2 (understanding science knowledge), compared to Graph 1 (which contains reports on planning), is due to the teacher's need to bring the discursive interactions to a closure, culminating with the formal presentation of the concepts. Although most discursive incidences relate to strand 3, since the teacher does not answer students' questions directly, but responds by posing a new question and inviting them to engage in science reasoning, over their development he anticipates some conclusions in the dialogs, moving from strand 3 to strand 2. This can be seen in the following episode – which contains E11, E12 and E13 in succession – where, with the ongoing interaction, the teacher ends up presenting the concept (science knowledge) directly.

> T: The lower case "m" that comes before Ampère is a prefix. What is a prefix?
> S2: Telephone prefix.
> T: Great, prefixes indicate values. If you have 1 Tera reais, will you remember that the teacher's car is a Classic? What is a Tera?
> S2: That depends on the person's modesty. (E11) strand 3
> T: How much is a Tera?
> S6: 1 quadrillion.
> T: Let's go parts . . . thousand, million, billion, trillion . . .
> S2: You could even afford a car . . . (E12) strand 3
> T: Just as Tera is worth that, mili is worth 10^{-3}. When the number has a minus sign in the exponent, it's divided. It's $1/10^3$. It's the thousandth part. In this case, it's 2 mA. Deci divides by 10. Centi by 100. Strand 2
> T: What is centi? (back to strand 3)
> S2: Divided by 100. (E13)

The interactions described in excerpts E11, E12 and E13 show the difficulty to sustain a practice focused on students' engagement in science reasoning. It is important to stress that although the teacher anticipates the conclusion when the dialogue is extended, he poses a new sequence of questions in an attempt to resume the process. This can be seen when he asks: *What is centi?*

The situation explored above and the accompanying comments evoke Schön's (1997) idea of reflection-in-action. According to this author, reflection-in-action is "... the process by which the teacher thinks about something that draws his attention during class, guiding himself in the intervention he will make in the situation to give a new meaning to what he is doing while still doing it" (Schön 1997, 33). In the case analyzed, the teacher reflects during his action, interrupting the dialogue that is becoming drawn out to pose a new question.

In concluding our considerations regarding the teacher's practice, it should be stressed that in relation to the process of assigning the dialogs to the a priori categories – strands 2 and 3 – they have nuances that sometimes hinder their differentiation. To classify the teacher's comments we used the following parameters: we assigned to strand 2 the presentation of a concept or definition without the generation of questions, reflections and/or explanations; we assigned to strand 3 situations in which a student asks a question and the teacher does not answer it directly, thus generating a discursive sequence, for understanding that engagement in scientific reasoning is taking place.

The lack of symmetry between what was perceived in the teacher's comments about his planning process and the observation of his classroom practice evidences the need to investigate teaching practice beyond interviews with teachers. As Schön stresses (1997, p. 90):

> It isn't enough to ask teachers what they do, for what they do and what they say often diverge. One must get at what teachers do through direct, recorded observation that permits a very detailed description of behavior and a reconstruction of intentions, strategies and assumptions.

Finally, closing the presentation of our interpretation section, we analyze the interactions between students and teachers during class, giving some examples of excerpts in the central column of Chart 6. In addition, as in the previous charts, the excerpts are numbered and assigned to a strand.

Chart 6 – Units of Meaning and Strands in Student Learning

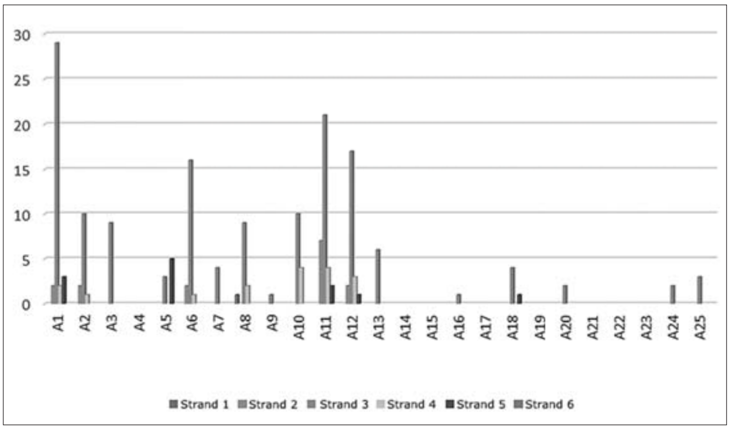
EXCERPTS	UNITS OF MEANING	STRANDS
17	T: S22 is having a barbecue for the class on Saturday. S2 is bringing the tomatoes. He says he wants a kilo of tomatoes. How many tomatoes is he bringing? S6: That depends on the weight of the tomatoes. S2: On the current price . . . S3: It depends on the volume and mass of the tomatoes. S6: Are they cherry tomatoes? (Laughs) T: He's bringing 1000 tomatoes. Class, kilo means one thousand. S2: It's kg! T: Ah . . . S2: So that's wrong, right, sir? We go to the butcher's and say: I want 3 kilos of meat . . . S6: What if you weigh 1300? T: That's a kilo and three hundred grams.	3
38	S6: By the way, sir, I have a cell phone app that counts how many steps I take in a day . . . T: That's nice.	5
74	S8: Sir, is scientific notation when the number is an integer? T: It doesn't have to be an integer. S8: To be scientific notation, do we have to divide the number by 10 until it's less than 10? S8: And when it's a high number, like 1000? T: You divide it by 10. For example, 1 million . . . How many times will you divide it by 10? Six times. T: 1 real is how many times less than 1000 reais? S12: 999. T: If I owe you 1000 reais and pay it back one real at a time, how many payments will I make? S12: One thousand. T: So how many times smaller is it? S12: 999 plus 1 is a thousand. You have to move the decimal point three places to the right. T: That's right. When I move the point to the right, I divide the number by how much? S12: By 10?	3

123	T: Class, and an airplane . . . when is an airplane a material point? When it's airborne. For example, it's flying over Brazil. S12: Sir, I've seen that when a plane disappears, a small dot appears representing it. Then its size doesn't matter . . . T: Class, I was watching the Pablo Escobar series, and he bought a plane and flew at a really low altitude to avoid the radar, right? S12: So radars are not totally perfect. They should improve the quality of radars.	4
136	T: S11, it's 40 m from here to the snack bar. How many steps do you need to take to get there, considering two steps per meter? S11: 80 steps. S1: If you run you get there faster. S12: You take fewer steps. S11: You take more steps; the speed is higher! T: Class, if you can keep the ratio at one step per half a meter, the number of steps will be the same. What will change is the time, right? You walk 40 m in less time . . . What ratio is it, what concept is related to that? S11: Distance and time. T: But what concept relates the distance covered with the time spent? S11: Speed.	3

Source: The authors.

As there is no space in this paper to transcribe the classes entirely, Graph 3 below features the number of manifestations of each student, contributing to the analysis and characterization of their learning.

Graph 3 – Characterization of Student Learning According to SSL



Source: The authors.

This graph shows a predominance of strand 3 (engaging in scientific reasoning) in student learning. Based on the premise that the SSL show evidence of science learning, one notes that the discursive interactions involving students occur in the investigation process, in the generation and explanation of evidence.

To conclude this section of data presentation and analysis, we include some descriptions that may clarify the analytical procedures executed, giving an idea of the *researcher's reasoning* in this process.

In one of the excerpts transcribed above (excerpt 136), the teacher proposes a question involving the concepts of speed, distance traveled and time. This related to the number of steps necessary to reach the snack bar at a ratio of two steps per meter, over a distance of 40 meters. S11 soon realizes that the answer is 80 m. When S1 interacts in the dialogue by saying, "If you run you get there faster" (raising a hypothesis), he introduces a notion of speed, leading S12 to mistakenly say that it would take fewer steps. S11 evaluates the evidence by saying that "You take more steps; the speed is higher!" The teacher intervenes at that moment, pointing out that the ratio of one step to half a meter will be maintained, and adds that what will change in this case will be the time it takes. When asked about the concept relating distance and time, S11 answers that it is speed, which is characterized as a sign of learning of this concept by the student. This discursive sequence represents a chain in an investigation process, and therefore we assigned it to strand 3.

In excerpt 17 the teacher asks the class a question regarding prefixes of measurement units. As the measurement unit of mass in the International System of Units (SI) is commonly referred to as kilo, not kg, the teacher uses this fact as a strategy to teach the concept. When he asks about how many tomatoes there are in 1 kilo, S6 and S3 interpret this as referring to kg and say that "It depends on the weight of the tomatoes," "It depends on the volume and mass of the tomatoes." When the teacher says that there will be 1000 tomatoes, S2 soon realizes that in this case, the correct unit is kg, thus understanding the difference between prefix and measurement unit. This discursive sequence also represents a chain of questions and answers in the search for evidence to solve a problem.

S6 says in excerpt 38 that he has a cell phone app that counts the number of steps taken per day. We can infer that this speech is related to strand 5, demonstrating how the student seeks information and uses technology (apps) to understand everyday facts. As stressed by Arruda et al. (2013, p. 16), "This is also the motivation for the pursuit of knowledge (strand 5 – engaging in scientific practice), whose sources of information are television, newspapers, people of work."

S12, in excerpt 123, in a dialogue with the teacher about material point and extended body, says, "So radars are not totally perfect. They should improve the quality of radars," referring to the accuracy of this apparatus. This statement, within the discursive sequence in which it is inserted, has characteristics that allow us to assign it to strand 4 (reflecting on science), because the dialogue relates to reflection on the precision of measurements and limits of science in the search for knowledge.

Final Remarks

The goal of this article was to characterize a learning configuration through the reports of a teacher about his planning of activities to be developed in the classroom. This led us to consider that the research/experimentation situations proposed by the teacher were *induced* by one of the Strands of Science Learning – strand 3 (engaging in scientific reasoning). However, due to the research questions raised, we started observing this teacher's classes over one semester in order to characterize his classroom practice, including the verification of whether what he had said in the interview agreed with what he actually did in class.

Graphs 1 and 2, featured in the previous section of this paper, showed moments of agreement and discrepancy, leading us to perceive that in the case investigated, it was difficult to achieve total symmetry between planning and execution. As we pointed out later, such changes may be related to several factors, among them the teacher's intention during the interview to avoid a connotation of *traditional lessons* and, during classes, the difficulty encountered in some moments to put such a perspective into practice (increase in the incidence of strand 2).

Having investigated the teacher's planning and practice, we started to seek evidence of student learning, attempting to verify whether such planning and practice *induced* by a strand of science learning resulted in student learning with the same characteristics found in that learning configuration. This was proven and can be easily observed in Graph 3, in which prevail discursive units assigned to strand 3. That was expected, since students' statements were, to a certain extent, induced by the teacher's discourse.

The quantitative analysis based on SSL categories and expressed in Graphs 1, 2 and 3 aimed to characterize the teacher's planning and classroom practice. The learning provided leads us to conclude that SSL may be considered a useful tool to understand and characterize a learning configuration. However, there are some weaknesses that must be worked on with deeper analysis and more focused systematization regarding the dialogues of the recorded lessons. An example: A single incidence in strands 4 or 5 may trigger discursive interactions that relate to strand 3, so there is a need to observe the entire process not only quantitatively, but to dedicate ourselves (which we will do in a research process following the elaboration of this first paper) to the study of those discourses and their interactions.

In short, the outcomes presented in this paper show that the strands of science learning play a relevant role in understanding teaching planning and practice as well as student learning in learning configurations involving situations of research and experimentation.

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Notes

1 One should recall that teacher learning can go way beyond mastering a subject such as physics or mathematics. In other words, in the T-K relationship, K may refer to what Tardif (2002) and other educators would call teacher knowledge.

2 All documents to be submitted to the analytical procedures (Bardin, 2004, p. 90).

3 This coding indicates that it's the teacher (T) speaking and is related to the 4th excerpt of his interview (E4).

4 To make the transcription and reading of dialogues easier, we chose to write the numbers using figures rather than words. The same goes for several measurement units.

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