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Inquiry-Based Science Teaching under Construction: Possibilities of Articulations Between Conceptual, Epistemic and Social Domains Within Scientific Knowledge in the Classroom

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In this paper, we analyse how a class discursively constructed articulations between the conceptual, epistemic and social domains of scientific knowledge. The first-grade class studied biological aspects of an insect. For data collection and analysis, we use Ethnography in Education as logic of inquiry. Our results indicate that the use of instructional resources, organised around questions, generated different ways of articulation between the three domains, evidenced in the participants' oral speech. The emphasis on the [epistemic+social] pair has given a more investigative character to the instructional context under construction. We also discuss implications for pedagogical practice and research in science education.

Keywords: domains of scientific knowledge, inquiry-based science teaching, ethnography in education, elementary school.

Introduction

In this article, we examine the way in which knowledge of the conceptual domain and of the practices of the epistemic and social domains of scientific knowledge were articulated in a sequence of science lessons. We intend to contribute to discussions in the field that seek to promote a learning process based on a more active role of the students, and based on more complex views of science, as a way to challenge traditional teaching based on transmission and memorization of scientific content.

One aspect that characterizes such proposals is a commitment not only to the presentation of the end product of science, but also to the engagement of the students in practices involved in the construction of scientific knowledge (Carvalho, 2018; Duschl, 2008; Kelly, 2008; Sasseron & Duschl, 2016; Stroupe et al., 2019). This is a challenging task for teachers, considering the processes for the socialisation of the students that is not restricted to concept-based learning (Kelly, 2013).

The innovative trends in science teaching show the potential presented by student involvement in practices such as argumentation, modelling and explanation; and that such practices are interconnected to the conceptual knowledge of science. However, the ways of promoting this association and its implications are not yet clear (Manz et al., 2020).

On the one hand, researchers have shown that explanation of how scientific processes work, teaching each step of scientific methodology or developing experimental activities so that the students may confirm conceptual knowledge, does not necessarily mean their introduction into the epistemic legacy of science (Stroupe, 2015; Manz et al., 2020; Ko & Krist, 2019). It would be necessary to create new opportunities so that the students could experience the construction of knowledge, appropriating whatever they are doing based on criteria used by science and collectively taking decisions (Carvalho, 2018; Ko & Krist, 2019).

On the other hand, the research warns of the risk of neglecting scientific concepts. Despite the need for restructuring of the curriculum, conceptual contents remain as a fundamental element of science teaching (see Carvalho et al.,2020; Mortimer et al., 2014), even in those approaches considered innovative (see Nascimento & Gomes, 2018). This indicates that there is a need for developing teaching proposals that add value to scientific practices articulated with knowledge of a conceptual ilk. In other words, concepts, models, and scientific theories should circulate in the classroom in a way that is tied in with to investigative processes (Sasseron & Duschl, 2016; Kelly & Licona, 2018).

In spite of these recommendations, as Ko and Krist (2019) emphasize, Science curricula are still largely based on a central axis of well-defined conceptual goals. With the teacher's work carried out around this axis, there is still a lingering tension with regard to how the concepts are taught. In the opinion of Duschl (2008), this tension is related to imbalance: the emphasis on the teaching of conceptual content seems to somewhat blind the proposal and engagement in scientific practices. These practices, in turn, get the students involved in processes for the construction of knowledge but do not always generate opportunities for conceptual learning.

Seeking new options to face such challenges, Duschl (2008) proposes that curricula should be planned based on a balance between the conceptual, epistemic and social learning goals of scientific knowledge. Inquiry-Based Science Teaching is an approach that has the potential to develop a more harmonic curriculum, not centred on concepts alone (Duschl, 2017; Kelly & Licona, 2018; Manz et al., 2020). However, research indicates that are challenges about how to promote this balance through an inquiry-based perspective.

In a review of the literature Furtak, Seidel, Iverson and Briggs (2012), show a prevalence of the conceptual domain in approaches to the learning that are not informed by inquiry-based teaching. These authors also emphasize that studies that have analysed inquiry-based lessons do not necessarily present evidence of articulations between the different domains. In some cases, the conceptual or the social domain have prevailed in isolation, while in other situations these two domains appear together. In other studies, the epistemic domain, was subdivided, thereby generating yet another domain, which has become known as the procedural domain. This "new" domain appears in studies related to hands-on activities, such as experiments that did not necessarily involve the mobilisation of epistemic criteria for the development thereof. In addition, there were studies in which the three domains were all identified, but the authors did not mention if this co-occurrence happens in an articulated fashion, or if the domains were independent of each other.

In a more recent review, Trivelato and Soares (2019) stressed some results previously obtained by Furtak et al (2012) and bring up other relevant aspects. In all the studies as analysed, there were some elements of the epistemic domain. The other two domains appeared less often. The prevalence of the epistemic domain arose from the very nature of scientific knowledge, something emphasized in inquiry-based approach. The conceptual and the social domains, despite their lower visibility, were also mentioned as being important in inquiry-based teaching however, there was no evidence of any explicit relationships between these domains in the studies analysed.

Duschl (2017) points out that some research in science education tends to defend the independent development of the three domains. This means that it would be more feasible to develop these in a non-articulated manner, giving more or less visibility to each one of them, depending on the teaching goals and objectives. In the opinion of the author, however, this kind of perspective makes it more difficult to establish a balance between the different goals of science teaching, which demands some effort in these articulations.

Uum, Verhoeff and Peeters (2016) provide some indications in this regard, on studying the way teachers give greater emphasis to a given domain, depending on the phase at which a classroom investigation occurred. At the initial stages of investigation, for example, there was emphasis on the conceptual domain; in the concluding stages, on the other hand, the greatest emphasis was on the epistemic and/or social domain. The authors warn that, even though a certain domain may be more or less emphasized at different moments, they must all be developed, as also should relations between them during an inquiry, a position stressed by Trivelato and Soares (2019). In this regard, to deepen the study of this issue, it is necessary to conduct research in science classrooms, as we still do not know much about how the articulations between the different domains occur in this context (see Franco & Munford, 2020; Manz, 2013; Uum et al., 2016).

In this article, we seek to contribute to such discussions, by analysing a sequence of science lessons, guided by elements from Inquiry-Based Teaching. We also strive to establish answers to the following questions: How does a class make use of knowledge from the conceptual domain and how does it engage in practices of the epistemic and social domains of science through a sequence of inquiry-based lessons? How does the class construct articulations, through discourse, between the three domains of scientific knowledge? We use data from a sequence of Science lessons at elementary school students from a class that we followed over three years. To construct our answers, we present analyses of its first year.

The domains of scientific knowledge and Inquiry-Based Science Teaching

Considering trends of Science Education over the last few decades, Duschl (2008) discusses the development of curricula, assessment models, and teaching. Even though this text is now over a decade old, we see that many of the challenges that have been raised in this work are still current today. In the light of the potential for epistemic understanding, scientific reasoning, and challenges for teaching, the author proposes a balance between the teaching goals and objectives linked to the conceptual, epistemic and social domains of scientific knowledge.

The conceptual domain is related to scientific explanations of the natural world and the corpus of knowledge that represents such explanations (Furtak et al, 2012; Stroupe, 2015). In the classroom, it represents "how theories, principles, laws and ideas are used by the actors to reason with and about" what is being studied (Stroupe, 2015, p. 1034), which is reflected in the construction of "of plausible models for representing and making sense of natural world" (Kelly & Licona, 2018, p. 142).

The study carried out by Manz (2013) offers good examples of knowledge of the conceptual domain and of the other domains. The author looked at science lessons about plant growth in 3rd grade, in a move seeking to characterise the three domains. In this case, knowledge from the conceptual domain in the classroom included: knowledge that plants produce seeds; knowledge that these seeds can 'fly', and that the seeds can give rise to new plants.

The epistemic domain, on the other hand, is linked to the use of epistemic criteria that the scientific community uses for construction of knowledge (Duschl, 2008; Kelly, 2008). Such criteria establish a foundation on which, in the classroom, "actors decide what they know and why they are convinced that they know it" (Stroupe, 2015, p. 1034), which helps the students to understand "the reasons, evidentiary bases for conceptual knowledge and models" (Kelly & Licona, 2018, p. 142). Manz (2013) identified the epistemic domain in the classroom, for example, when the students, faced with different ways of explaining why plants grew in the school's backyard, made use of collected data [the seeds "travel"] to support the explanation the group was constructing. Thus, with the support of criteria similar to those used in science itself, the students had to deal with different ways of explaining a phenomenon, and made use of an item of data as evidence for the construction of their statements.

Kelly (2008), Furtak et al. (2012), Ko and Krist (2019) and Stroupe (2015) suggested that some practices are connected to the epistemic domain: processes aimed at data collection and reflections about how such processes should occur; construction of evidence based on work with data to explain natural phenomena; interpretation and analysis of evidence; use of alternative explanations and changes in explanations for phenomena, based on analysis of evidence.

Last but not least, the social domain is related to opportunities to understand "processes and contexts that shape how knowledge is communicated, represented, argued, and debated" (Duschl, 2008, p. 277). In the classroom context, as proposed by

Stroupe (2015), a reference is made to the way in which the "actors agree on norms and routines for handling, developing, critiquing and using ideas" (p. 1034). As highlighted by Furtak et al. (2012), the social domain involves methods of collective construction of knowledge, through which students can make their ideas public, work in collaborative fashion, and make decisions together. In the study carried out by Manz (2013), the author characterised the social domain within situations where the students answered each other, disagreed, asked questions about these disagreements, and also took into account the contributions made by colleagues during the discussions about plant growth.

In this study, we use these indications to analyse activities and interactions in the classroom, associated with the notion of Inquiry-Based Science Teaching, under construction. As Duschl (2017) highlighted, one possible option to promote integrated work between the three domains of scientific knowledge is Inquiry-Based Science Teaching.

There are different ways of understanding Inquiry-Based Science Teaching and of implementing it in the classroom (see Pedaste et al., 2015; Strieder & Watanabe, 2018). In the broad sense, we see it as a didactic approach that proposes that, instead of just learning what science has created through memorisation of names and formulae, handling symbols and calculations, it would be important for the students to gain closer contact with the process of knowledge production (Carvalho, 2018).

The expectation behind such proposals is not that the students shall behave like, or shall become, scientists in their own right, as there are differences between goals, methods and contexts in the "school science" and "the scientists' form of science" (Munford & Lima, 2007). The proposal in this study is to create a favourable environment for students to engage in ways of acting through which the scientific community constructs knowledge (Carvalho, 2018) without, however, creating any kind of stereotyped and trivialised view of science (Munford & Lima, 2007).

The diversity of the ways in which this proposal materialises in the classroom makes it more difficult to have one single definition of the approach among science teachers and researchers. In addition, we observe distorted views of inquiries in the classroom. These end up reducing inquiry-based teaching to one-off pedagogical strategies, often confused with practical or experimental activities, or proposals with the only aim of awakening the students' interest in science (see Cardoso & Scarpa, 2018).

The study and analysis by Strieder and Watanabe (2018), for example, stresses the plurality of meanings ascribed to inquiry-based activities. In spite of diversity, the authors point to common aspects that have warranted greater or less visibility, depending on the perspectives used. One of these aspects refers to the goals of inquiry-based teaching, revolving around the learning of science and/or about science, the development of scientific attitudes, and the understanding of (and participation in) the contemporary world. In some approaches, the goals focus on inquiry-based teaching itself, while, in others, the inquiry occurs as a way of teaching other content, such as concepts, characteristics of science, or issues concerning students' reality.

The review by Pedaste and collaborators (2015), on the other hand, takes another direction, but also helps us understand some elements common to the different references. The authors organise the results of the research on the issue into five general phases of inquiry-based activities. In a first phase, known as orientation, there would be stimulation of the students' curiosity with regard to the topic to be investigated. This phase would be followed by conceptualisation, where there would be the presentation of the issue to be investigated and by the drawing up of hypotheses that could explain it. Later, the students would move on to the phase of investigation, which would involve planning processes, exploration, experimentation, and data collection and analysis. Finally, the activity would have its conclusion, where students should establish their conclusions based on their analysis, comparing the inferences made with the hypotheses raised and the initial questions of the research. The authors also talk about a discussion phase, which could permeate the whole activity in its different phases. This would be the process of presentation of results at each phase or at the end of the investigation, which would involve communication with peers and/or a general reflection about the process.

These and other analyses of the research in Science Education (see Carvalho, 2018; Seung et al. 2014) highlight the fact that, even though there are different forms of identification of elements present in Inquiry-Based Teaching, there is a certain degree of stability about what is often considered essential in this approach. In addition, as mentioned in analyses such as those of Pedaste and collaborators (2015), it is also important that we bear in mind that there are variations that are indeed important. In this respect, Cardoso and Scarpa (2018) warn that the establishment of structures or proposals for diagnostic tools to be applied in inquiries does not mean the presence of one single linear way to carry out inquiry in the classroom.

This means that if, on the one hand, there are many indicators about what should be present in a series of lessons for the sequence to be taken as inquiry-based and attempts to establish shared indications, on the other hand we must take into account that things do not unfold homogeneously in our classrooms (Kelly, 2013). For example, planned activities with large inquiry potential, when developed in certain instructional contexts, are in fact not inquiry-based lessons, which leads us to consider that "inquiry-based teaching goes well beyond written inquiry-based activities for the students" (Carvalho 2018, p. 767). Many are the contextual elements that could have an influence on if and how inquiry takes place, ranging from wider-scope curriculum policies and sociocultural issues (Sasseron, 2018; Franco & Munford, 2018), to specific characteristics such as the academic background of the teacher of a specific class group, the pedagogical philosophy of the school, or the degree of contact between the students of the group and different pedagogical approaches (Kelly, 2013; Munford & Lima, 2007).

In this regard, we feel it would be productive to analyse and reflect upon the essential elements of inquiry-based teaching, based on the contexts for insertion of this approach. This allows us to implement a more efficient articulation between educational theory and pedagogical practice, considering the way in which teachers and their students negotiate and share inquiry-based teaching in a construction process.

One good example in this regard is Monteira and Jiménez-Aleixandre's (2015) study These authors discuss how small children investigate the biology of periwinkles, over six months. The children explore questions to discover, among other things, whether "periwinkles have mouths", if "periwinkles have teeth", and "where the mucus comes from" in the case of periwinkles. On thinking about the questions raised by the children, it is possible to consider that these would not be inquiry questions. For example, we should think about the limitations of these questions, on proceeding with the development of inquiry stages as proposed by Pedaste and collaborators (2015) or authors with similar views.

However, Monteira and Jiménez-Aleixandre's (2015) discussion leads us to consider some contextual elements, such as the level of schooling of the group analysed and the process for introduction of small children to the way answers are constructed in the realm of science. At the start of schooling, it is necessary to bear in mind that students establish their first distinctions, within the school, distinguishing between answers stemming from opinion or imagination and those reached based on observation. Thus, multiple answers can appear, on asking oneself, for example, what a periwinkle's mouth would be like. On stressing the need to go to the periwinkles and then try to identify the periwinkle's mouth and observe it, the teacher of that particular group introduced one specific way of constructing answers. This action proved to be important for the analysis by the authors, especially with regard to the way in which small children started to reconsider their ideas after each inquiry. Therefore, we could consider that certain questions that required such observations would not themselves be inquiry-based. However, when put into context, such issue takes on a new meaning, guided by an inquiry logic, as they provide the students with resources about how knowledge shall be constructed when they are in their science lessons.

These indications are relevant for the analyses of the present article. There could be some expectation (possibly frustrated) that the children would follow the guidelines as proposed by the "inquiry-based teaching canon", so that the teacher would then be able to guide them, for example, through the phases proposed by Pedaste et al. (2015) or other investigation structures. This did not happen. Even so, we are considering the approach used by the teacher as being inquiry-based, bearing in mind the articulations between the three domains of scientific knowledge, as shown by our analyses.

Our research team followed this class between the first and third grades. In the first learning sequences, carried out in the first year, the team's participation was more significant, often giving the lessons themselves. However, the lessons we have analysed in this article are part of a first sequence the teacher planned and developed without much intervention from our research team. Another aspect worthy of note is that at a later moment, in the third year, we observed a greater appropriation of an inquiry-based approach, not only by the teacher but also by the children themselves (see Franco & Munford, 2017). The teacher's repertoire when facilitating the inquiry-based science lessons also became richer over time. We also noticed the recurrence, transformation and diversification of investigative practices students constructed (Cappelle, 2017).

We understand that Inquiry-Based Teaching is always undergoing construction in the classroom. However, when we talk about Inquiry-Based Science Teaching under construction, we seek to emphasise an instructional context[1] in which a class started its path in inquiry-based Science teaching, with activities that, in theory, could not be taken as inquiry-based activities. Such activities, however, generated opportunities for the students to construct their own "inquiry logic" throughout the science lessons. As we shall mention and discuss in our analyses, this process was enabled based on the way in which the domains of scientific knowledge were articulated, as also based on the emphasis given to the [epistemic+social] pair during the course of the lessons as here mentioned.

Theoretical-Methodological Backgrounds

The present study was based on assumptions and tools of Ethnography in Education (Green et al., 2005; Bloome et al., 2008; Castanheira et al., 2001) and also the work of authors from Science Education (Duschl, 2008; Kelly, 2008; Stroupe, 2015). We followed the activities of one same class group during the first three years of Primary School, in Natural Science lessons, between 2012 and 2014.

Guided by Ethnography in Education, we aim to view the classroom as culture, through analysis of how the participants in this space, namely the class teacher and the students, "define, structure, give meaning to, and place value upon a set of everyday activities" (Bloome et al., 1989, p. 270). Thus, we see the classroom as more than just a place where one teaches/learns instructional content, or where a certain set of values is transmitted (guidance for the future). The classroom is regarded as a space where interactions may be interpreted based on what "doing a science lesson" actually means for the people involved (Bloome et al., 1989).

With this purpose, we followed the daily activities of this class, constructing a historically localised analysis and establishing connections between specific events and the wider history of the group. Based on an ethnographic perspective, an event is a heuristic for analyses of how people construct their daily routine (Bloome et al., 2008) and the processes for selecting the events to enter the analysis reflect the way in which we lead our investigations within the class that we have followed.

Based on representations such as timelines and descriptive charts (Castanheira et al., 2001) we analysed events with greater detail, which allows evidence relationships between the part(s) and the whole, all considered within the history of the group (Green et al., 2005). Based on this "panoramic" view, obtained through macroscopic analyses, we pinpoint events of greater interest for research purposes, making selections in the data set (Wolcott, 1994).

Within the three years we have monitored, we ended up selecting a set of lessons of the first year of primary school. As we shall discuss later on, we obtained evidence that events that occurred during these classes were highly significant for the class group

1 The notion of instructional context refers to the activities proposed for the classroom, and the relations between these activities and their possible effects upon the learning process (see Bloome & Green, 1982). In this case, when we mention instructional resources in our analyses, we refer to the tasks set by the teacher, such as: written activities, drawing, text composition, and group discussions.

itself, which is a key aspect for Ethnography in Education. The ethnographic perspective seeks to give greater visibility to the participants' points of view, looking into everyday life practices based on a more emic (native) perspective rather than on an etic (from outside) one (Green et al., 2005).

Also seeking to add value to the viewpoints of the classroom participants, we consider the core role of discourse as a semiotic tool based on which people can construct their routine practices (Bloome et al., 2008). This means that, apart from description and wider analysis of a set of events, we have also selected two specific events, based on which we shall exploit face-to-face interaction between the participants so as to understand articulations that have been constructed based on discourse, between the conceptual, epistemic and social domains of scientific knowledge in the classroom.

On speaking of articulations "constructed based on discourse", we invoke what ethnographers in education have called "talk into being" (Dixon & Green, 2005). We have analysed discourse interactions in the classroom, starting out from the assumption that "discourse does not express actions: it is itself the action" (Bloome et al., 2008, p. 71). This means that, whenever students and/or the teacher use language through interactions, whether verbal or non-verbal, they "act upon and with others" (Bloome et al, 2008, p. 18, our translation, italics added). Based on the way in which participants act and react to each other, during and throughout the science lessons, meanings are constantly being negotiated, shared, and modified. Thus, we give greater visibility to the deep relationships that exist between language and culture, as constructed by social groups in everyday lives (Dixon & Green, 2005).

The Research Setting

The study took place in a public lottery school in the Southeast region of Brazil. In this article, we shall highlight the first year of the project, as the analyses here presented refer to lessons that occurred when the class group had just entered school, in the first year of elementary school.

This year, the class had 25 students (15 girls and 10 boys), who studied at different institutions of Early Childhood Education. Here we must mention the ethnic, social and economic diversity between the children. The Science classes were given by teacher Karina[2] , who was also responsible for Portuguese lessons. Karina had a PhD in Education and she had worked for 25 years as a teacher. Her experience with science teaching was similar to that of most elementary/primary teachers: Karina had much expertise in the area of language and literacy, but lacked significant contact with science teaching. This had certain consequences for the instructional context, as both the teacher and the children were having their initial contact with the field of science education using an inquiry-based approach. The lessons described below are those of the first year, as

2 We have used pseudonyms to identify the teacher and the students. To preserve privacy and well-being of the research subjects (Spradley, 1980), the children were consulted in advance and the children also received oral explanation about the research and about how the data would be collected and used. This project was subjected to the approval by the Research Ethics Committee of the responsible institution, and the adults involved – parents, teacher, and trainees – were also consulted and signed an Informed Consent Form.

shown in Table 1 below.

Table 1. Programme of Science lessons in the first year of Primary School

Year	Term.	N° of lessons	Main topic	Key activities
1st Year	1st	13	Growth of plants; plant diversity	Elaboration of questions; work with experiments (different plants placed under different conditions); making observation of the experiment in the classroom and in the school yard; data collection; conclusions.
	2nd	13	The biology of the Cricket	Visits to the school yard; observations of animals; elaboration of questions, study of birds; discussion of what animals need to live.
		9	The biology of the stick bug	Observation; data collection and analysis, and argumentation regarding growth, sexual dimorphism, and eating habits.

Out of this total programme of 35 lessons, in this study we focused on the lessons addressing the topic: "The biology of the stick bug", as shown in summarised fashion in Table 2 below.

Table 2. Synthesis of lessons about 'The Biology of the Stick Bug'

Lesson	Themes	Key Activities
1	Introduction to the study of the stick bug	The class starts Reading the book 'The dilemma of the stick bug' and the teacher then suggests that the students prepare questions about the insect.
2	Morphology and camouflage in the stick bug	The students continue to read the book and produce a drawing with the title of: 'I think a stick bug is like this...'
3		The students finalize their reading of the book, and then discuss camouflage in the stick bug, which is the main subject covered by the book.
4		The students are given three stick bugs, in the classroom. In groups, they make observations about the morphology of the stick bugs and then make notes.
5	Behaviour, growth, feeding, and sexual dimorphism of the stick bug	The students use different leaves to feed the insects, then note down the insects' behaviour and discuss the moulting process.
6		The group discusses the insects' eating habits, also noting down the behaviour and the size of the animals.
7		The students discuss the identification of the sex of the stick bugs, as also their eating habits and the moulting process.
8		The students then discuss, and resume the debate about sexual dimorphism in the stick bug and in other animals.
9	Growth of the stick bug and conclusions of the study	The students observed the baby stick-bug, recording the animals' size, and then preparing in groups a written text to present conclusions.

This sequence of lessons about the stick bug started with the children preparing questions. This is an aspect that helps us to understand, in a more general form, the instructional context of the lessons. In the very first lesson, Karina wrote on the board: 'What do I want to know about the stick bug'? The students then responded to this question and Karina noted down, on the blackboard and in a notebook. Some of these were selected during the lessons. In addition, some other questions came up during the lessons for further investigation.

The answers to these questions were constructed based on work with data. Some questions were answered by argumentation and/or by working based on raw data (Monteira & Jiménez-Aleixandre, 2015), that is, a set of information that has not yet been analysed and which makes up a database. This database had information that was selected based on three sources. Figure 1 presents a summary of the questions that guided the discussions connecting them to the different sources of data used during the lessons:

Observations made with a specific purpose	**Experiment**	**Second-hand data**
✓ Lesson 4 — the children observed the insects in the classroom, to answer questions: "how many legs do they have?", "how many antennae do they have?" ✓ Lessons 4, 6 and 10 — the children measured the animals with a ruler, to answer the question: "what is their size?" ✓ Lesson 9 — the children measured the new stick bug, to answer "Is the insect born big?"	✓ Lessons 4 and 9 — the children offered different types of leaves to the insects, to answer "What do stick bugs eat?" ✓ Lesson 5 — observation of leaves of the Brazilian cherry (*Eugenia uniflora*); ✓ Lesson 6 — observation of leaves of lettuce and of jaboticaba (*Plinia cauliflora*); ✓ Lesson 7 — observation of mango and guava leaves; ✓ Lesson 8 — observation of leaves of the jambo (*Syzygium jambos*) and of the blackberry vine; ✓ Lesson 9 — observation of eucalyptus leaves.	✓ Lessons 1 to 3 — the class discussed 'why does it look like a toothpick?' and 'what does it like to hide from others', based on the information on camouflage contained in the book 'The dilemma of the stick bug'; ✓ Lesson 6 — children used information about the stick bug to answer questions about egg laying and size, based on book references and on Internet research.

Figure 1. Guiding questions and sources of information for the establishment of the database

The way the sequence was developed, the guiding questions, and also the process for construction of the answers, showed that the investigation did not follow a single model. There was no commitment to development of fixed phases or stages, within this approach. Therefore, the group did not follow one same investigative path throughout the programme of lessons. Thus, this sequence makes it possible to better understand how inquiry-based science teaching was starting to be part of the repertoire of this particular group. As we discussed, considering the instructional context experienced at that moment (2nd term of the first year of elementary school), we then started to understand the sequence of lessons that we have analysed, as a good example of what we consider "Inquiry-Based Science Teaching under construction", in the light of the connections between the three domains of scientific knowledge in the classroom.

Data construction and analysis

The construction of the data occurred based on participant observation (Spradley, 1980), and also recording of observations in a log book, as well as audio and video recordings and collection of classroom activities (Green et al., 2005). The process of macroscopic analysis was constructed based on a Lesson Chart with general information about Science lessons during the three years of the project. Based on the chart, as also based on field notes, we elaborated a Timeline with a focus on the characteristics of the instructional context of Science lessons. It is a representation of the key activities as proposed in each lesson, over the three years.

Based on the timeline, we have selected the set of lessons about 'The Biology of the stick bug', considering its analytic potential for the present study. Guided by the ethnographic perspective, we have drawn up a historical analysis (Bloome et al., 2008). Both in 2013 and in 2014 we identified classroom interactions in which students refered back to events that occurred during their lessons about the stick bug, as well as, they used knowledge constructed in these lessons in investigations that took place in the future. Events of the lessons on the stick bug were invoked as a resource in new discussions by the class group. This provided us with evidence that what took place during these lessons was significant for the group.

As we have mentioned, the group was having their initial contact with Inquiry-Based Science Teaching. Once again, guided by the ethnographical perspective, we understand that the analysis of the beginning of certain paths has strong potential for research, considering that at these moments the ways in which the group negotiates roles, routines and expectations for the lessons become more visible (Green & Wallat, 1981). The children were in the first year, starting investigations within their science lessons, and the teacher conducted the sequence of lessons with greater autonomy than before. In previous sequences, at the start of the first year, members of the research group participated more actively in the lessons, suggesting activities or even leading some of them. In the lessons about the stick bug, however, the research group played only a secondary role. Karina was responsible for the planning of the activities, and for leading them. This gave greater visibility to the way in which the group established rules, routines, and ways of participating in the lessons.

Based on studies in the area of Science Education (Duchl, 2008; Kelly & Licona, 2018; Stroupe, 2015), we analysed how the class group made use of knowledge and how they engaged in practices of the conceptual, epistemic and social domains of science, throughout the series of lessons on the stick bug. This analysis was constructed based on the questions that guided the science lessons. This means that there was not necessarily an organisation of the results based on the chronological order of the lessons. Activities and discussions, used by the group as resources for the instructional context, appeared in different lessons during the process for construction of answers. This means that the analysis assumes the need for a continuous movement along the timeline showing the history of the group, depending on how the participants constructed answers for each of the questions of interest.

In addition, we construct representations to show articulations between the three domains of scientific knowledge during these activities. Finally, we explore two events for an analysis of discourse interaction. These events were selected using a criterion based on greater visibility of these articulations within the oral discourse of the participants.

For analysis of these events, we transcribed the interactions, word for word, in message units. The message unit represents the smallest meaningful unit in analysis of a discourse interaction, and reflects the way in which the participants in a group construct shared limits within interactions (Green & Wallat, 1981). These limits were identified through contextualisation cues shown in speech, such as changes in intonation, emphasis, speed, pauses, posture, glances, gestures and so on (Gumperz, 1992). In the transcriptions, we use symbols to identify the cues and then the message units were grouped into interaction charts.

Results and analysis

Initially, we discuss knowledge and practices of the conceptual, epistemic and social domains, based on the organisation of the group, for the construction of answers to the questions raised in Lesson 1, as also other questions that arose later. The first questions were related to the morphology of the insect (including "how many legs do they have?", "how many antennae do they have?", "what is their size?"). Figure 2 summarizes this knowledge and these practices, linking them to resources used in the instructional context in the lessons analysed:

Conceptual Domain	Epistemic Domain	Social Domain	Instructional Context	Lesson
The stick bug has six legs and two antennae.	Establishment of distinctions between personal opinion and imagination and the use of observable data.	Process of communication of what is observed, and negotiation about how the records shall be produced, for morphological characterisation.	Children produce two drawings: "I think the stick bug is like this..." and "The stick bug is like this". The children make direct observations of these animals and the teacher discusses the difference between the drawings, based on what has been observed.	2–4

Figure 2. Knowledge from the conceptual domain and practices of the epistemic and social domains, with regard to questions about the morphology of the stick bug

Knowledge of the conceptual domain, related to the identification of the morphological characteristics of insects, was used in articulation with practices from the social and epistemic domains. These articulations became more evident based on the specific way to make knowledge legitimate in science lessons, as the teacher requested in Lesson 4: with the arrival of three stick bugs to the classroom environment, to make statements about knowledge, it would be necessary to have observable data rather than just imagination or personal opinion.

In addition, there were processes involving negotiation between the children and the need to reach a consensus about what was being observed. In Lesson 4, during the small-group observation activities, there were disagreements regarding the characterisation of the insects. For example, the number of legs that each student was able to identify on the insects; the number of antennae; and the presence of a stinger were some points that rose doubts. The teacher made some interventions in each group to help students reach a consensus, based on a session where everyone had the chance to say and show what they were observing. This emphasized the way in which the group was collectively constructing a work routine. Thus, practices from the social domain were also identified, articulated with the practices of the epistemic domain.

Despite being more visible in Lesson 4, such articulations only make sense based on what the group was already constructing in previous lessons. In Lesson 2, Karina had requested the production of a drawing with the title: "I think the stick bug is like this…" The students would then make their drawings based on their imagination and on prior knowledge. In Lesson 3, the teacher went back to the drawing activity, showing structures that the students had drawn: eyes, mouth, legs, antennae, stinger. The task of Lesson 4 was then to prepare a second drawing called "The stick bug is like this…" The main purpose was for the students to distinguish between this drawing and the drawing of Lesson 2. Karina selected some drawings to show, for example, some images in which the insects had been represented with twenty legs or six antennae; this highlighted the difference from what was later observed, with the insects having six legs and two antennae (Figure 3).

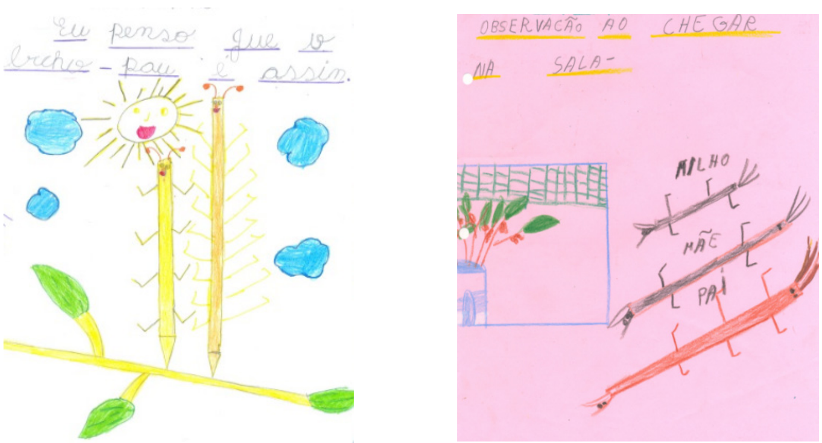


Figure 3. Drawings prepared by student Karla in Lesson 2 and Lesson 4, respectively

In this contrast, the articulation between the domains of knowledge became more significant: i) there are morphological differences between the first drawing ("I think the stick bug is like that…") and second drawing ("Observation as it arrived in the classroom") [size of insects, number of legs, number of antennae], ii) it is necessary to make observations in order to draw in Science lessons [rather than just imagining what the insects would be like], and iii) it is also necessary to share what is being observed with the group, and have a group discussion.

The questions about the morphology of the insect are not inquiry-based questions. However, the analysis of the connections between the different domains helps us understand how the instructional context was constructed based on an inquiry logic. How did the group construct the answers? The teacher changed the epistemic criterion between Lesson 2 and Lesson 4 [imagination>observation], which brought consequences for the whole dynamics of legitimation of knowledge. The new criterion is close to that used in science [observation and use of data] and was immersed in social dynamics [whatever the classmate observed had to be taken into account]. Thus, the [epistemic+social] pair gave shaped questions as investigative, even though they initially were not investigative.

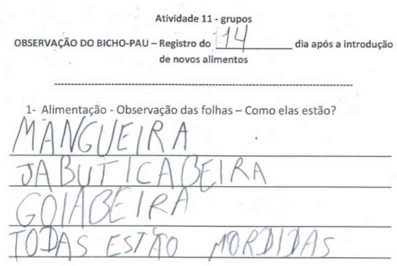
As from Lesson 4, the observation of the insects involved a work routine with the three stick bugs, which stayed in the classroom environment up until Lesson 9. Apart from using raw data to discover something, as occurred between Lesson 2 and Lesson 4 (How many legs? How many antennae?), the group also started to use the data to sustain or to revise an idea or conclusion, between Lesson 5 and Lesson 9. Thus, the class constructed answers for the questions about the insects' eating habits, their growth, and their sexual identification.

In the experiment on the insects' eating habits, which started in Lesson 4 and which was finalised in Lesson 9, the children used evidence to say which plants the insects would consume as food . In this process, we identified knowledge and practices from all three domains of scientific knowledge, as shown in Figure 4.

Conceptual Domain	Epistemic Domain	Social Domain	Instructional Context	Lesson
Animals eat specific things. The stick bug eats guava leaves, jambo leaves, jaboticaba (*Plinia cauliflora*) leaves, and leaves of the Brazil cherry (*Eugenia uniflora*). Stick bugs do not eat lettuce or black mulberry (*Morus nigra*).	Collection and analysis of primary data through an experiment. Use of an alternative explanation for the differences observed between the leaves.	Disagreements regarding the identification of leaves that were bitten into and those that were not.	The children put into the terrarium different types of leaves and, observing each one, they sought to identify bite marks on the leaves.	4–9
	Use of the conclusions to sustain an idea.	There is a need to reach a consensus about which leaves should be placed in a terrarium for the future baby stick bug.	Karina suggested the construction of a terrarium for the eggs. The children agreed to use the Brazil cherry rather than lettuce, so that the stick bug babies would have food available.	8

Figure 4. Knowledge of the conceptual domain and practices of the epistemic and social domains of Science, with reference to the question about the eating habits of the insects

The knowledge of the conceptual domain was obtained based on a criterion that indicates engagement in practices related to the epistemic domain of science: an experiment offering different leaves to insects every day, analysing marks on the leaves and written records of the results in a logbook (Figure 5).



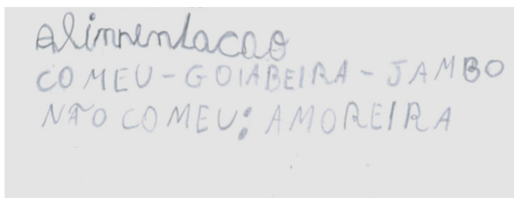


Figure 5. Records of observations of leaves (The first, produced by Marcelo, shows that leaves from the mango, jaboticaba and guava trees had all been bitten. The second, produced by Nara, shows that the insects had eaten jambo and guava leaves, but not blackberry vines.)

The analysis of the marks on the leaves is important for the establishment of links between the three domains. Specifically, in Lesson 8, when the group discussed the experiment carried out with the leaves, and we selected an event in which the role of articulations becomes more evident in the oral conversations. After the break, Karina resumed the discussion[3] (Figure 6):

Line	Speaker	Speech
1	Teacher	I asked Adriana I
2		To observe I
3		If the stick bug had eaten blackberry leaves I
4		What do we see there Adriana ↑
5		*Come forward and speak I Adriana gets up and goes to the front of the class*
6	Camila	If it eats it then- I
7	Teacher	Do you know Adriana ↑
8		She is going to speak now I
9		Adriana I
10		When you observed the blackberry vine leaf I
11		What did you see ↑
12	Adriana	There were some curves I ▼ With her right hand, in the air she draws the curves in the leaf
13	Teacher	There were some curves on the leaf I
14		Draw them for me, please I Adriana takes the chalk and draws on the blackboard
15		Yes, that's it I
16		When you saw this curve on the leaf I
17		What did you think ↑
18	Adriana	That it was from the bite I ▼
19	Teacher	That it was what ↑
20	Adriana	That it was from the bite I
21	Teacher	That it was from the bite I
22		But then we went to look at it I
23		And what did we discover ↑
24	Adriana	That they were just curves in the leaf
25	Teacher	That it was just a curve in the ↑
26		Le+af I
27		Just a curve that the leaf itself had I
28		But it was I

Figure 6. Interaction Chart 1 (to be continued)

3 Symbols used in transcription: ↑ rise in intonation; I pause; ▼ low speech volume; + lengthening of a vowel.

Line	Speaker	Speech
29	Teacher	Eaten ↑
30	Adriana	No ǀ ▼
31	Teacher	It was not eaten ǀ
32		It was from the leaf itself ǀ
33		So ǀ Adriana goes back to her seat
34		We recorded this on the 26th ǀ

Figure 6. Interaction Chart 1 (continuation)

The "curves" on the black mulberry (*Morus nigra*) leaves were not bites, but marks that were present in all the leaves (l24–27), a morphological characteristic of that particular plant. Up until that moment, the students were thinking that the insects ate jambo and blackcurrant vine leaves. The intervention by Adriana, actually a very timid student, changed the conclusion about the eating habits of these insects. The criterion she used was observation of the leaves. This criterion is not trivial and is not immune to disagreements between the observers.

None of the children had observed the insects when they were eating a certain leaf. What happened was that, with every lesson, the children would remove the leaves from the terrarium and then observe possible bites. A bitten leaf was evidence that the animal fed on that particular type of leaf. This means that the class group was using data to sustain their conclusions about the insects' eating habits. The epistemic criterion was therefore linked to the social domain of scientific knowledge: there was disagreement between the children, right from the very first day of observation. They disagreed about whether marks were present or absent. In Adriana's case, this disagreement was even more significant, as this was a matter of questioning whether all the marks that everyone observed were in fact bites, or possibly a characteristic specific to that type of plant. Thus, the student used the data as support, but queried it, using an alternative explanation for what was observed. Going back to the interactions immediately prior to the class leaving for break, we were able to gain a better understanding of the disagreement that Adriana had generated. Karina had called upon Ricardo, Ramon and Adriana to go over to the terrarium to observe the black mulberry leaves. These three students were arguing between themselves (Figure 7):

Line	Speaker	Speech
1	Ramon	My goodness, Zé ǀ
2		Those that are "dark" ǀ *Ramon pointed to some jambo leaves and black mulberry leaves, these being mixed together inside the terrarium*
3		And because of their slobber ǀ *Adriana and Ricardo were handling some black mulberry leaves and feeling the markings on the leaves*

Figure 7. Interaction Chart 2 (to be continued)

Line	Speaker	Speech
4	Ricardo	Óh I *Ricardo points to a marking on the blackberry vine leaf*
5		The insect ate it I
6	Ramon	This time I am going to speak I
7		This is a guava leaf ↑ *asking Adriana directly*
8	Adriana	No I
9	Ramon	Black mulberry I
10	Adriana	Aham I
11	Ramon	So here I go I
12		Blackberry vine *I the students go back to their places*

Figure 7. Interaction Chart 2 (continuation)

This discussion between the three students was not shared with the rest of the class group at that moment. The teacher asked the group to complete their written records, with regard to the observation of leaves of the jambo plant (*Syzygium jambos*), but there was no conversation about the black mulberry. Ramon and Ricardo believed that the insects had eaten the leaves of the black mulberry (L4–6). Ramon mentioned the slobber of the insects on the leaves as evidence backing up this conclusion (L1–3).

In this case, there were articulations between the domains of knowledge, to the extent that a practice linked to the social domain of Science [disagreement with peers] took place within the process of appropriation of a practice linked to the epistemic domain [come up with an alternative explanation for the data as observed] so as to change knowledge in the conceptual domain that was under construction [the eating habits of the animal studied]. Once again, the [epistemic+social] pair added an investigative aspect to the question: the teacher had nurtured disagreement before they reached a consensus, favouring the visibility of the criterion Adriana had used.

It is also worth mentioning possible differences between the observation made by Adriana, Ricardo and Ramon and those comments raised in Lesson 4. In these, the children had made more direct observations to identify and count the number of legs and antennae of these animals. As from Lesson 5, however, the routine of observation of eating habits required a different relationship to data, to which the group was still being introduced: the statements would be backed up by evidence of a certain phenomenon, rather than by direct observation.

The process of negotiation of the question on the eating habits of the insects was also relevant to answer another question, a more methodological question that came up in Lesson 8. In this lesson, there was a discussion about the differences between eggs and faeces, with regard to the construction of an "eggs house". The teacher suggested that the eggs in the terrarium should be separated and placed in a smaller terrarium, so the children may observe them more easily, should a new baby stick bug be born in the coming days.

Karina explained that not all the "blobs" on the floor were eggs. The teacher pointed out that there were faeces as well as eggs. Samples were passed around the class, for observation, and the students identified differences in format and colour. After this distinction between eggs and faeces was duly made, four eggs were identified, and the children then constructed the "eggs house". During the assembly process, Karina asked which types of leaves should be placed in the new terrarium. That particular day, they had two types of plants available: lettuce and the Brazil cherry (*Eugenia uniflora*). In spite of some initial disagreements, eventually the children agreed that Brazil cherry leaves should be used instead of lettuce, so that the new insect could already have food available at birth. Therefore the discussions about eating habits brought opportunities for new connections between the different domains of knowledge, as shown in Figure 4: knowledge of a conceptual ilk [stick bugs lay eggs; eggs are different from faeces; the eating habits of stick bugs] was mobilised to sustain ideas [the house should contain Brazil cherry leaves], with this bringing a need to reach a consensus [would the chosen leaves be lettuce leaves or Brazil cherry leaves, and why?]

Other articulations were constructed based on the question about the growth of the insect (Figure 8). In this case, the instructional context comes closer to what has been considered essential for inquiry-based teaching: based on a natural phenomenon, an inquiry-related issue led to the raising of hypotheses which, in turn, were analysed based on the data available, leading to certain conclusions.

This started in Lesson 5, when the children noticed something different in the terrarium. Something that they first thought was a dead stick bug generated a new question. Indeed, the 'novelty' in the terrarium was not actually a dead stick bug, but rather the exuviae from the young insect. On growing, the young insect had released the cuticle of its exoskeleton, a kind of shell which, to the children, looked like a dead stick bug. The teacher did not mention the children's misunderstanding. She started a discussion, pointing to each stick bug within the terrarium, showing that there were still three live insects. Thus, the teacher tried to show that what they were seeing would be something new inside the terrarium.

An exemple of knowledge from the conceptual domain [the stick bug grows by moulting] was linked to practices of the epistemic domain of science, as students came up with different hypotheses to explain the phenomenon. Ricardo thought that a fourth stick bug may have entered the terrarium and then died. Mauricio considered that there was a fourth stick bug in the terrarium, camouflaged right from the start, and then it died. Jonas said that a new stick bug had been born during the night and did not survive. Finally, Breno suggested that this could be one of the stick bugs already in the terrarium that shed a kind of "skin". These possibilities were then discussed based on some data that the teacher took up. Karina reminded the class group that the terrarium was sealed off with netting, meaning that it would be very difficult to sustain Ricardo's proposal. The teacher also remembered that the leaves were changed every day. This would make Mauricio's proposal very unlikely. So Ricardo suggested that if it were a new stick bug that was born during the night (Jonas' hypothesis), then there would have been a broken eggshell inside the terrarium. However, Ricardo did not find this shell, which weakened the proposal that Jonas had raised.

Conceptual Domain	Epistemic Domain	Social Domain	Instructional Context	Lesson
The growth of the stick bug occurs through moulting.	Observation of the natural phenomenon and preparation of hypotheses to explain it.	Students disagree about how one can explain the presence of the dead stick bug in the terrarium.	A "dead stick bug" is found in the terrarium and the children come up with four possible hypotheses that could explain this phenomenon.	5
	Use of data to appraise hypotheses and sustain explanations.	Ricardo tries to find an eggshell that would confirm Jonas' hypothesis. Breno agrees with Karla's example to confirm his explanation.	Karina resumes the issue of previous events and data about the size of the young stick bug. Children compare the different sizes of the animals.	5
	Reaching conclusions.	The children reach a consensus, agreeing that there was a shell in the terrarium.	A debate ensues, regarding the core issues studied up to that moment.	7
	Use of a previous conclusion to explain the new phenomenon.	The children agree to use the previous conclusion to explain the new observation.	Children make new measurements and comparisons, when a second moult appears in the terrarium.	9

Figure 8. Knowledge within the conceptual domain, and practices from the epistemic and social domains, related to the question about the growth of the insects

The teacher then returned to records of raw data: the measurements of the animals that the children had taken. The small insect was 5 cm long when measured in Lesson 4, and then 6.5 cm in the new measurement in Lesson 5. The larger insects maintained their size. In addition, the alleged "dead stick bug" was about 5 cm long. While Karina annotated these measurements, Karla suggested that maybe something similar to what happens to snakes could have taken place. These animals shed their skin and grow a new one. Breno argued that that shell in the terrarium could belong to the young stick bug.

Thus, getting engaged in practices of the epistemic domain, children raised hypotheses and used primary data so that the hypotheses could be analysed. The practices were constructed based on disagreements between the students, who had to reach a consensus with regard to their explanations. This factor highlighted the social domain of knowledge under construction, as it involved consideration of what other people thought, with the construction and sharing of group conclusions, based on the work with data.

These conclusions were not shared in Lesson 5. However, in later lessons we see that Breno's idea prevailed within the group. In Lesson 9, for example, a second shell appeared in the terrarium. Karina suggested that a new measurement be made: the young individual was 8 cm long. The second shell was larger than the first, but less than 8 cm. Karina then remembered Breno's proposal, highlighting the measurements made in Lessons 4, 5 and 9. The class group then agreed that the insect grows through these "changes of shell", and then the trainee teacher present in the classroom said that this process is known as moulting, this being knowledge from the conceptual domain that had been discussed, especially in Lesson 5.

The path trailed by the group in this discussion is close to what has been considered an inquiry-based instructional context. However, this does not mean that this is a finished process, based on which the group had already taken direct appropriation of a certain investigative "outline". Historical analysis shows that the discussion on the "dead stick bug" occurred in the midst of all the other discussions about the biology of the stick bug, where we found elements that sometimes are distant from, and other times are close to, the instructional goals of inquiry-based science teaching, characterising the process through which the group was taking its first steps in the construction of investigations like a "set of instructions" for science lessons.

Finally, we exploited the articulations that we noticed based on discussions of the question about sexual dimorphism in insects (Figure 9).

The conceptual domain involved awareness of, and use of, knowledge such as: the male is smaller than the female; the male has wings and there is no universal standard in nature to define sexual dimorphism. The construction of such knowledge involved engagement in practices related to the epistemic domain of science: collection and use of primary data, based on the observation of the insects' morphology and behaviour pattern; collection and comparison of secondary data, based on reference materials and on research on other animals; review of ideas and use of conclusions for the construction of new statements.

Practices of the social domain appeared in articulated fashion, linked to the other two domains. Ever since Lesson 4, there has been a series of disagreements about the identification of the insects' sex, as also regarding the criteria to be used by the group to make this distinction. The students considered contributions they had made to each other, eventually arriving at a consensus about the three criteria used for the identification, taken up again in Lesson 9, which also highlighted the routine for collective construction of knowledge.

Conceptual Domain	Epistemic Domain	Social Domain	Instructional Context	Lesson
The female is larger than the male	Preparation of an argument based on the observation of the animals and on scientific reference materials.	Students disagree about the sexing of the insects.	Evandro comments that the small one is on top of the large one, and then Karina starts a discussion about sexual differences; Marcelo e Evandro use data from books to declare that the female is larger.	6
	Preparation of arguments based on the observation of animals, and on a causative relationship.	Students disagree during sexing of the insects, and come up with opposite arguments.	Mauricio defends the view that the male is larger, as it eats more and must keep an eye on the young baby animal. Breno defends the view that, as the female has the babies, it eats more and is therefore bigger. Ricardo defends the view that the male is smaller because it gets more nervous.	7
	Review of ideas, reaching conclusions.	The children reach a consensus with regard to the determination of the insect's sex.	The children carry out a written activity and then prepare a group text: distinction between male and female.	9
	Use of conclusions for the construction of new statements.	The children agree to use the previous conclusion to explain the new phenomenon.	Faced with the new stick bug, the children said that it would not be possible to establish its sex. It would be necessary to let it grow.	9

Figure 9. Knowledge within the conceptual domain, and practices from the epistemic and social domains of Science, related to the question about the establishment of the insect's sex

Conceptual Domain	Epistemic Domain	Social Domain	Instructional Context	Lesson
The male stick bug has wings.	Collection of primary data.	Children take into account the contributions made by a colleague, on resumption of discussion of criteria for sexual identification .	Ester notices that the smaller animal has wings, as part of the routine observation of the stick bugs. Her classmates use the presence of wings as a criterion.	7–8
There is no set standard for distinguishing between male and female animals, in nature.	Collection and comparison of secondary data.	Disagreement between the students (some did not accept/consider the possibility that the female could be bigger).	The children use and compare morphological differences between males and females of different animal species (macaws, peacock/peahen, lion/lioness etc).	8

In Lesson 4, as shown, most of the children considered that the biggest animal was the "father", the middle-sized one was the "mother" and the smallest one the baby. Even so, there were disagreements. Karla, for example, suggested that the mother could be bigger, and Lara raised the possibility that there may not be a father in the terrarium, just a mother and two babies.

Later, this discussion was taken up again in Lesson 6, during the observation of the animals' behaviour. Evandro reported that the small insect was on top of the large one and that it would be the male, disagreeing from the position taken by the majority. Different data came up to sustain opposing views. Marcelo and Evandro mentioned the information from an encyclopaedia and a book, respectively, to defend the view that the female was larger than the male. On the other hand, Camila made comparisons with her family members to defend the opposite view, and also appraised her classmates' comments, saying that information in books could not be true. This discussion did not go any further at that moment, and the prevalent idea was that the larger animal would be the male.

In Lesson 7, the teacher proposed the simulation of a television programme, so that the children could discuss the issue of sexual identification of animals, as well as other issues that the group had studied, with regard to growth and eating habits. With regard to sexual identification, a variety of arguments arose, based on the animals' morphology and patterns of behaviour. Maurício's view was that the male would be bigger because it eats more and because it would have to care for its baby. On the other hand, Marcelo and Breno felt the female would be larger because it needed to eat more, as it is the female that gives birth to the babies. Ricardo's opinion was that the male would be smaller because the smaller animal seemed more nervous, just like his own father at home who is very nervous. No conclusion was reached with regard to this discussion, at that moment.

In this case, once again we mention that the [epistemic+social] pair gave the instructional context a more investigative character. Considering that the question that gave rise to this debate would not in itself be investigative and the fact that there is no explicit conclusion, historical analysis says that the arguments raised by Marcelo and Breno prevailed over time. This means that, in later classes, most of the children started to believe that the larger animal would be the female.

In this process, the epistemic criterion that prevailed in the group was based on the relationship of cause in the argumentative construction made by Marcelo and Breno. This was possible thanks to the engagement in a debate opened in Lesson 7, and which led to a change in the categorisation as made by the children up to that moment. Therefore, the group added value to the arguments that used criteria closer to those used by science, faced with a diversity of opinions raised by the peers during the debate itself and also in previous classes. Even without a formal conclusion along the lines proposed by inquiry-based teaching, historical analysis shows that the group did indeed reach a conclusion, albeit in an implicit way, with regard to sexual dimorphism, as observed in Lesson 9.

In this class, the children noted down something surprising during their observations: a stick bug had been born in the egg terrarium. Karina then proposed making a written record of this event, as a group. In this event, the role of articulations between the three domains was more evident in the oral discourse of the group (Figure 10).

Line	Speaker	Speech
1	Teacher	On the 28th a baby stick bug was born I *Karina was writing on the board and Reading the phrase she had written*
2		And the egg was still stuck to the leg ↑
3	Ramon	<u>*His leg I The teacher writes the word "his" on the board*</u>
4	Breno	Teacher I
5		There is something else I
6		You need to put that little wall with an "a" [4]I
7	Teacher	A++ I
8		The wall I
9		What is the name of the little wall↑
10	Breno	It is like this, right I *Makes the movement of brackets in the air, using both hands*
11		(...)
12	Teacher	Why do you want I
13		Us to put it here, in the brackets?
14	Breno	Like this. yeah I *Breno gets up and goes over to the board to show it*
15		The "a" I
16		If I put the "a" here, right I
17		On his or her leg I

Figure 10. Interaction Chart 3 (to be continued)

4 The letter "a" to which Breno refers is a suffix in Portuguese. The difference between male and female in this case is just because the letter "a" at the end of a word. For this reason, Breno suggests the use of a little wall – brackets – to indicate that the collective text should consider two possibilities: his (her) leg, which in Portuguese is "perna dele (a)".

Line	Speaker	Speech
18	Teacher	Bu+t ǀ
19		Why do we put this↑
20	Mariana	Because w+e ǀ
21		Don't know ǀ
22		Because we don't know ǀ
23	Teacher	You don't even need "but" now ǀ
24		Now it is a "because" look ǀ
25		A baby stick bug was born *reading from the board* ǀ
26		The egg is still sticking to his or her leg ǀ *reading from the board*
27		Because w+e ǀ *speaks while writing on the board*
28		This way there is no need to add "or" ǀ
29		That's right ǀ
30		Because we ǀ
31		No what↑
32	Mariana	We know if it is male or female ǀ
33	Teacher	We know if it is male or female ǀ *Repeats Mariana's words while writing on the board*
34		Ma+le ǀ
35	Mariana	Or female
36	Teacher	Now I want to know something here ǀ
37		When someone is going to read this ǀ
38		When we hand it over for them to read ǀ
39		Then they will say ǀ
40		I don't think these boys really know about it ǀ
41		They can't even say if it is male or female ǀ
42	Mariana	I kn+ow ǀ
43		If when it grows ǀ
44		It's ve+ry big ǀ
45		That's because it is a female ǀ
46		Or if it grows ǀ
47		And lays an egg ǀ

Figure 10. Interaction Chart 3 (continuation)

The articulations between the different domains, in this case, occur when knowledge from the conceptual domain [criteria used for establishing the sex of insects] is mobilised while the students are involved in a practice from the epistemic domain [use of data to back up a statement], a process generated through a practice related to the social domain [an intervention with the collective construction of the statement]. Construction of a statement means the use of the criteria as negotiated previously, namely: size [the female is larger than the male] and egg laying [the female lays eggs].

The reference to the baby stick bug as being a male [his] (L3) would not be sufficient in the light of what the group already knew at that moment (L5). However, Breno's intervention would need to be justified. Mariana said it would not be possible to identify the sex of the baby stick bug (L22 and 32), meaning that it would be necessary to observe its growth and/or laying of eggs (L42-47). Thus, even though there was no final conclusion about the sexual identification of the insects, this event shows that involvement in the debate started in Lesson 7 was a decisive factor to make the largest stick bug "become" female, which students systematised when a new phenomenon required the use of this conceptual knowledge.

The analysis of these interactions (Interaction Chart 3), in contrast with the previous discussions (Interaction Charts 1 and 2) also show some relevant aspects in the way in which the group was establishing the links between the three domains. On discussing the eating habits of the insects, we see a movement of the practices of the epistemic and social domains towards the knowledge of the conceptual domain. This means that, through engagement in certain practices, the group constructed conclusions about what insects eat (and what they don't eat). On discussing dimorphism, we observe movements in a different direction. The conceptual knowledge that the group had already constructed [sexual identification] was mobilised while they elaborated record of observation collectively, this being motivated by the disagreement as to how the text should be written, followed by the demand for justification. In other words, the children were using conceptual knowledge to get involved in practices of the epistemic and social domains of science.

The analysis of instructional resources the group used when constructing their answers indicates that these movements involving articulations between domains also occurred at other moments during the lessons. It is possible to identify a movement of the practices of the epistemic and social domains towards the conceptual domain right from the very first lessons, when there was the establishment of the criterion of observation for the production of drawings of the insects, and that it would be necessary to share this with the group and also negotiate what was being observed. Such practices led the group to reach a group conclusion regarding the characterisation of morphological elements of the stick bug. A similar movement was also observed in the discussions about the moulting process: based on practices of drawing up hypotheses and use of data, the students, who disagreed among themselves, reached a consensus around an explanation of the phenomenon that had been observed in the terrarium.

A movement in a different direction was observed in relation to the discussions on the construction of an egg house: from the conceptual domain to the epistemic and social domains. In this case, the students used the conceptual knowledge about the eating habits of the insects while involved in practices of the epistemic and social domains, on deciding which leaves would be placed in the new terrarium.

Conclusions and implications of the study

Among other aspects, the social function of Science teaching involves the creation of opportunities so that children and adolescents may be able to understand and use scientific ways of explaining the natural world (Carvalho, 2018; Kelly, 2013). However, the use of scientific concepts, theories and models still occurs in an aseptic way, detached from questions about nature or about the criteria that are socially used in the construction of knowledge. Thus, introduction of students to the conceptual legacy of science requires curricula that can establish articulation of engagement in practices related to the epistemic and social domains of scientific knowledge (Duschl, 2008). Part of the research in scientific education has given visibility to such domains but in an isolated way, thereby favouring, more or less, certain elements of the purposes of science learning (Uum, 2016).

An alternative to these challenges is the use of Inquiry-Based Science Teaching. There is a lot of controversy with regard to the many different ways of understanding and developing this approach in the classroom. Faced with this scenario, we present analyses of an interesting case: a teacher and her students who, on starting out with the use of the inquiry-based approach in the classroom, constructed a curriculum where different scientific domains were articulated. These articulations were significant for the introduction of the students to an inquiry logic that backed up and supported the "doing a science lesson" for this group.

With regard to our first research question, we have said that the group used conceptual knowledge and got engaged in practices of the epistemic and social domains, based on a work format based on questions. To answer these, the group went along different paths, sometimes getting closer, and other times distancing from the canonical models of inquiry-based teaching. The class group used a database, experimental data, and secondary data to prepare answers that are more direct or to sustain or revise their conclusions through presentation of evidence.

With these results, we do not intend to exhaust all the possibilities of the work of the teacher and the students with the different domains of scientific knowledge. These possibilities are quite diverse, as we have said, and this has been backed up by results from our research (Furtak et al., 2012; Manz, 2013; Uum et al., 2016). Based on the answers to the second research question, we argue that the group of participants took two different paths in constructing articulations between the domains. One related to the use of conceptual knowledge for the engagement in practices of the epistemic and social domains; the other related to the engaging in practices of the epistemic and social domains for the construction of knowledge of conceptual domain, as shown in Figure 11. Continuing research in science classroom contexts will make it possible to improve current knowledge about this process.

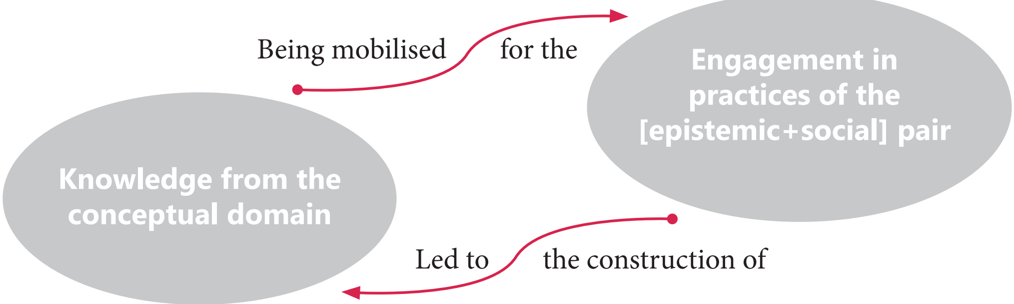


Figure 11. Paths for the construction of articulations between the conceptual, epistemic and social domains in the classroom

For example, if the teacher proposes activities which request the students to “mention some data that backs up your hypothesis”. We believe there is epistemic knowledge involved in this situation. However, let us now suppose that this kind of activity is not part of communicative demands involving discussion, representation and argumentation in science lessons. We would then run the risk of transforming epistemic knowledge into just another set of “rules” to be followed or memorised (for example: mentioning the source, mentioning data, linking data to conclusion).

To what extent are activities involving epistemic knowledge able to generate an involvement in practices of the epistemic domain? This is a complex issue that requires deeper understanding of the Science Education field (Pierson, Clark & Kelly, 2019). We agree with authors who have shown the need to place the students as epistemic agents, instead of just showing a declarative style of learning scientific processes or the reproduction of skills linked to what is known as the “scientific method” (Kelly & Licona, 2018, Ko & Krist, 2019, Stroupe et al., 2019).

Our analyses show that the practices of the social domain enhance epistemic knowledge in the classroom. It was this process that gave a more investigative character to the instructional context for this class group. This makes us understand that epistemic knowledge should not be taken to the classroom in a hermetic manner; otherwise, we could end up teaching in a way similar to what, as a rule, happens with knowledge of the conceptual domain: out of context, and to be simply declared. In the past, there were moments where one tried to introduce the scientific method along these lines, which proved to be limited for the promotion of student involvement in epistemic practices (Pierson, Clark & Kelly, 2019). Hence, we feel that epistemic knowledge can only be genuinely appropriated as an epistemic practice if it is immersed in practices from the social domain.

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