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► To cite this version:

Luciana Moro, Eduardo Mortimer, Andrée Tiberghien. The role of social semiotics multimodality and joint action theory in describing teaching practices: two cases studies with experienced teachers. 2019. halshs-01997858

HAL Id: halshs-01997858

<https://shs.hal.science/halshs-01997858>

Submitted on 25 Feb 2019

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The use of social semiotics multimodality and joint action theory to describe teaching practices: two case studies with experienced teachers

The aim of this study is to better understand how teachers use various embodied semiotic modes - speech, gestures, gaze, and proxemics – when they present scientific content to the entire class. To analyse the multimodal practice of these teachers, we integrated the social semiotic theory of multimodality and the joint action theory in didactics. We use a case study methodology to analyse the video data and to describe the productions of two teachers from selected short episodes. The results show several similar elements of these teachers' practices. In particular, their use of several coordinated modes to make a coherent meaning to complex aspects of scientific knowledge such as three- dimensional representations of chemical structures or the relation between an experiment and its model of light diffraction. Both teachers create signs by taking everyday things from their environment to re-signify them in a scientific way. Simultaneously they maintain contact with their students through their gaze and their position. In this way, they create or strengthen the classroom habits related to the explanation of knowledge.

Keywords: multimodality; joint action; embodied modes; teacher's performance

Introduction

The phenomenon of multimodality is not new. Conversation, for example, was always multimodal; we resort to several modes beyond language – gestures, gaze, posture and proxemics – to make meaning.

Jewitt (2008) claims that the way knowledge is represented, along with the mode and media chosen, is a crucial aspect of knowledge construction that makes the form of representation a full part of meaning and learning more generally. She defends the need to explore ways in which representations in all modes are enacted in the classroom. Although language is widely considered the most significant mode of communication, particularly in contexts of teaching and learning, meanings are made, distributed,

received, interpreted and remade through many representational and communicative modes – not just through oral or written language.

In science education, the implications of multimodality are even greater. Lemke (1998, 87) notes: “Science is not done, is not communicated, through verbal language alone”. Accordingly, he identifies the concepts of science as semiotic hybrids that are simultaneously verbal, mathematical, visual-graphical and actional-operational. Thus, multimodality seems to be a crucial feature to consider when studying the teaching and learning of science.

Multimodality in science learning has been the subject of several studies focusing on various aspects of teaching and learning. Studies focused on students’ conceptual understanding and learning difficulties, where external multi-representations play an important role, for example, on spatial reasoning in astronomy (Subramaniam and Padalkar 2009; Padalkar and Ramadas 2011), on particular models in changes of states (Prain, Tytler, and Peterson 2009), on geological sedimentary processes (Herrera and Riggs 2013) or on the work-energy concept (Tang, Tan, and Yeo 2014). All these studies focus on multimodal building of science concepts and support the view of a concept as “publicly displayed forms of situated meaning-making practices with multiple semiotic resources” (Tang et al. 2014, p. 1799) instead of a hidden mental structure residing inside the human mind.

What these studies on multimodality do not focus is on the performance of teachers, considered to be the ways by which they integrate objects from the milieu in their joint action with their students to build pieces of knowledge. In this process they use different semiotic resources [that are related to their performance](#) – which include gestures, speech, gaze and proxemics.

Norris (2004) classifies the modes as embodied and disembodied. Embodied modes are those in which one uses his/her body or a tool that is directly connected to his/her body to produce meaning. In a disembodied mode, a person does not use his/her body directly to produce meaning.

Related to Norris's distinction, we use multimodality to investigate the way a teacher uses an ensemble of modes for making meaning as a whole (Kress 2010), a part of them being embodied modes to construct performance in the classroom. In this sense, multimodality represents a set of actions that a teacher can use to improve his/her performance. There are not many studies that take the [teachers'](#) performance as its subject. Embodied modes have been used to examine, for example, the ways in which teachers and students negotiate and manage speaker change in IRE sequences (Kääntä 2012), but not to analyze the teacher's performance when they explain scientific content.

Our study is situated in this trend and focuses on the science teachers, laying down a multimodal interactional approach that relates didactic and social semiotic approaches. In this way our study aims at combining two theoretical frameworks - social semiotics and didactics - to better understand how teachers use an ensemble of signs to communicate meaningful science knowledge.

More specifically, the aim of this study is to better understand how two experienced teachers use multiple embodied modes to make pieces of meanings of knowledge available when they communicate to the whole class.

Theoretical framework

Our framework integrates these two pragmatic approaches - social semiotic multimodality (Jewitt 2008; Kress 2010) and the theory of joint action in didactics (Sensevy 2011) - to account for the specificity of multimodality in all of the teacher's

and students' actions during classroom teaching.

Joint action theory

The basic idea of the joint action theory in didactics is that human action is thought of as a *joint action in a pragmatic orientation*; more specifically, teaching and learning are two joint actions. This theory involved two main concepts: the didactic contract and the milieu. The *contract* is defined as the strategic systems used by the teacher and the students to carry out the different tasks. The *milieu* consists of the elements of the material and the communicational situation that allow the teacher and students to construct or modify a new strategic system by building a new piece of knowledge. Sensevy and Forest (2011) view the teaching/learning relationship as a semiosis process in reference to Peirce (1998), or in other terms “as the way of producing and deciphering signs”. The students have to decipher the teacher's signs and also the signs of the milieu and the teacher similarly has to decipher the students' signs and the signs of the milieu. These authors refer to the Peircean semiosis process in a general sense, as they characterize this process in the framework of the joint action theory. They, for example, do not use the Peirce classification of signs (iconic, indexical, and symbolic).

This perspective of joint actions is also approached with studies on action coordination or, in other terms, on how the actors integrate the ‘what’ and ‘when’ of others' actions in their own action planning. This affects the perception of object affordances and permits joint anticipatory action control (Sebanz, Bekkering, and Knoblich 2006, 75).

The concept of milieu is associated with the notion of affordance. Affordance (Kress 2010; Gibson 1986) is related to the idea that different modes offer different potentials for making meaning. Each mode has its own semiotic logic. *Speech*, for example, happens in time, as one sound follows another. That sequence in time is one

fundamental organizing principle for making meaning in this mode. *Image*, on the other hand, is displayed on a surface in a usually framed space, in a way that all of its elements are simultaneously present. In this sense, this simultaneity of the different elements and how they relate to each other in space is the fundamental organizing principle for making meaning in *image*. Thus, while speech has a rich potential to portray temporal relations, image has a rich potential to portray spatial relations.

The potential milieu, on the other hand, includes all aspects of the environment, particularly the institutional one, the “state of affairs”, and the material world. In terms of semiosis, the milieu consists of all the signs that can be deciphered by the actors (Sensevy, Gruson, and Forest, 2015). The effective milieu is what the teacher and/or the students really decipher to develop their strategy, whereas what is available is the ‘potential milieu’; thus, the milieu can be different for the teacher and a student, as the same object or utterance can take different meanings for them. They can select and decipher the signs differently. [Although "affordances" and "milieu" belong to different theoretical traditions, both refer to elements of the environment which teacher and students can use to decipher science.](#)

The concept of a didactic contract, which is strongly related to the milieu, allows us to make sense of the teacher’s and students’ actions. Their strategies to select and use elements of the environment are directly linked to the meaning making. These strategies lead them to make and decipher the signs. This leads us to emphasise a semiotics approach in which we focus on the teacher’s action, at least in this article.

This approach offers a framework for the study of classroom practices. The concepts of milieu, and didactic contract allow us to describe and give meaning to the teacher’s action in classroom practice; thus, the study of multimodality is not performed

for its own benefit but to expand our understanding of teaching and learning in the classroom.

Multimodality and modes

A social semiotic approach to representation and communication sees all modes as meaning making systems, all of which are integrally connected with social and cultural systems (Kress 2003). Kress and others (2005, 3) affirm that meaning is made by individuals, who act in social environments and use socially and culturally shaped available resources. This approach shares commonalities with pragmatics (Bezemer and Jewitt 2009). In particular, it emphasizes the situated perspectives of communication and meaning in a context.

Jewitt (2008) affirms that modes are constantly transformed by their users in response to the communicative needs of communities, institutions, and societies: New modes are created, and existing modes are transformed. According to Kress (2010), meaning exists only as it is materialised in one or more modes.

The question of modes includes that of semiotic resources. For example, following Bezemer and Jewitt (2010, 184), we consider that:

Social semiotics assumes that resources are socially shaped to become, over time, meaning making resources which articulate the (social, individual/affective) meanings demanded by the requirements of different communities. These organised sets of semiotic resources for making meaning (with) are referred to as *modes*.

Multimodality and semiotic resources

Semiotic resource is a key term in social semiotics (van Leeuwen 2005; Jewitt 2006). It originated from the work of Halliday (1978), who argued that the grammar of a language is not a code or a set of rules for producing correct sentences but a resource for making meanings. Considering that the semiotic system is simply there to be used and

understood, Van Leeuwen (2005) states that 'semiotic resources' include semiotic modes such as language, gesture, images and music along with food, dress and everyday objects, which, according to him, carry cultural value and significance.

In this approach, people express meaning through their selection of the semiotic resources that are available to them at a particular moment. This is close to joint action theory. Teacher and students use the milieu as semiotic resources, and according to the contract, the teacher and the students can construct their own resources to produce new meaning.

Kress (e.g. 2001, 2009) introduced the notion of ensemble that includes all the signs which contribute to make meaning in a communicational process. Based on our observations that teachers use some objects of the environment to make sense inside the classroom, we will consider semiotic resources as acts, objects, procedures, and practices in the classroom. Since we consider that meaning making processes are built using an ensemble of signs, it does not make sense to analyse gestures separated from speech and from a projection on the screen in classroom contexts.

Specific semiotic resources

In our study, we will consider several semiotic resources that emerge in the use of some modes, from which we will highlight speech, gesture, proxemics, gaze and posture. It is important to note that all these modes are implicated in meaning making but that in the classroom, the teacher always uses them along with other semiotic resources, such as a projected image, an experimental apparatus, or a ball and stick model.

Speech

According to Ferreira, Algodoal, and Silva (1998), when we hear a voice, we can

evaluate it in terms of several parameters: pitch, loudness, resonance, rhythm of speech, the articulation of sounds and voice quality. Several studies claim that these are prosodic features. In this work, we are particularly interested in evaluating changing pitch, loudness and rhythm of speech, including pauses, which are part of these traits but cannot be confused with prosody, which is much more complex.

With regard to pitch, what interests us in this article are changes in vocal pitch because these changes determine certain patterns of intonation, which characterise the intentions of the teachers in the process of meaning making. The same can be said about loudness, as someone uses stronger loudness to reinforce a message. Finally, pauses are seen as an important mechanism in the pace of communication between people. Pauses can also be used to highlight words according to the intention of the teacher, to plan the continuity of speech and to organise parts of speech (Gonçalves 2000).

Gestures

Gestures are spontaneous idiosyncratic movements of the body that people enact in synchrony with speech (McNeill 2005; Kendon 2004). In this study, we use the classification of gestures proposed by Kendon (2004), which is based on gesture functions. According to him, gestures can be classified into two broad categories, referential and pragmatic.

The *referential* gestures are part of the referential content of the respective utterance. These are divided into: a) *representational* gestures, which provide representation of an aspect of the content of utterances, which are subdivided into: *modelling* gestures, when a body part is used as a model for an object; *enactment*, i.e., action gestures, when the gesturing body parts engage in a pattern of action similar to what is being said; and *depiction*, when the speaker sculpts and/or outlines the shape of

the described object or "creates" the object in the air; and b) *deictic* gestures (or *pointing*), when the speaker points to the object (concrete, virtual or abstract) of reference in the utterance.

The *pragmatic* gestures relate to aspects of the meaning of an utterance that are not part of its referential meaning or propositional content. The pragmatic gestures are subdivided into: (a) *modal* gestures, which have an enhancer function, for example, giving emphasis; (b) *performative* gestures, which are used to indicate the type of speech act a person is engaging in (e.g., a request, an offer, an invitation, a refusal); for example, the open-palm-up is used to indicate that what the speaker says is being offered to the interlocutor; and (c) *parsing* gestures, which are used to punctuate speech and to show its different logical components.

According to McNeill (2005), *catchments* are recognised from two or more gestures (not necessarily consecutive) with partially or fully recurring features of, e.g., handedness, shapes, movements, space, orientation, and dynamics. The *catchment* is the recurrence of a common idea or image that is displayed by the speaker through the re-enactment of a gesture with a particular pattern. Thus, catchments convey a semantic association to the listener, even when directed to different objects or different contexts that contribute to the establishment of coherence for the listener.

Proxemics

In a classroom, there are interpersonal communicative events in which the teacher and student serve as stimuli to each other. Each participant in these events has at his/her disposal a variety of verbal and nonverbal behaviours with which to sustain or terminate an interaction. Proxemics involves phenomena akin to the tone of voice or even stress and pitch in the English language (Hall 1963). In this study, we are concerned with the

distance that teachers have from students along with the object of knowledge (Forest 2006; Sensevy and Forest 2012). This idea of distance developed by Forest (2006) is deeply embedded in the joint action theory in didactics; this distance is one of the characteristics of the milieu and thus the teacher's proxemics habits is a part of the didactic contract (the students expect the teacher to be at a given distance according to the type of classroom activities). We consider that teachers can be physically distant from students because they need to keep themselves near the representation of knowledge on the board. However, they can be close to the students by keeping their gaze and body orientation directed toward them.

Gaze

During social interaction, it is common to look at the other person for approximately 50 per cent of the time, according to Kendon (1967). In ordinary naturally occurring social interactions, directing one's gaze, and interpreting another's gaze, is one means by which participants organise their activities and make sense of what they are doing. Participants use their gaze to help determine who is talking to whom, to attend to objects and events, and to orient themselves within the immediate physical environment (Nevile 2010).

Multimodality and joint action theory in science education

In science education there are many works that resort to multimodality to understanding what happens in the teaching and learning processes. Givry and Roth (2006) stated that the studies of students' conception cannot be reduced to verbal productions and should include available speech, gestures, and contextual structures. Other studies focused on the science content itself. Lemke (2000) considers that the scientific curriculum requires students to use specialized verbal, visual, and

mathematical literacies quickly and fluently in real time during physics teaching in secondary school.

[Tang, Tan, and Yeo \(2011\)](#), Danielsson (2016) and He and Forey (2018) used a variety of analytical techniques based on Halliday's Systemic Functional Linguistics to analyse how teacher and students integrate different modes of representation in meaning making different concepts related to the teaching of work - energy, atom and digestion. Danielsson (2016) and He and Forey (2018) also investigate both the semiotic affordance of an individual and an ensemble of modes. All these studies show how students and teacher deal with the difficulties in integrating written and spoken language with mathematical symbolism, drawing, gestures, animation, etc.

[Tang, Delgado, and Moje \(2014\)](#), on the other hand, construct a framework through integrating research on how students build scientific understanding through the simultaneous use of various modes within and across representations (multimodality) and research on how the use of more than one representation affects students understanding (multiple representations). This reflects in their choice of units of analysis, which was done in two dimensions: timescale and compositional grain size. Generally speaking, multimodality studies are characterized by shorter timescale and finer compositional grain size and multiple representation studies by longer timescale and larger compositional grain size. In using the two dimensions they are able to build a four-quadrant framework in which they can situate different studies throughout the four different types that characterize this quadrant.

Hubber, Tytler, and Haslam (2010), and Tytler (2013) consider that teaching should help students to learn to represent, and re-represent ideas in different modes; they emphasize the idea that understanding concepts requires coordinating their different representational modes, a representational mode being only partial. They

develop and analyse teaching and learning situations where students generate and negotiate their own representations, and also learn the standard representations and thus can acquire a metacognitive understanding of the role of representations.

There are few papers (quoted above (Sensevy and Forest 2012) and Sensevy, Gruson, and Forest 2015)) that deal with the joint action theory and include multimodal analyses. Their analyses are focused on the evolution of the dialectic didactic contract and milieu.

In our case, the use of social semiotics as presented below should allow us to better understand how the teacher uses the embodied multiple modes and external supports to give meaning to scientific knowledge in the classroom. *We use general ideas that come from Systemic Functional Linguistics but we do not use its analytical techniques to show how the teacher resorts to different semiotic resources in the process of making meaning.* Our interest is on how these two teachers combine the particular way of using things they have in their milieu, and their embodied modes as an ensemble to make meaning of scientific knowledge. In this sense, we are going to emphasize how the teachers enact embodied modes such as speech, gesture, gaze and proxemics, create rhythm together with the use of elements of the milieu, and use catchments (McNeill 2005) to help students to understand scientific conceptual knowledge. In doing so, we investigate how the teachers establish a specific didactic contract for building knowledge meaning.

Research question

This article pays attention to embodied modes that contribute to enhance the performance of two experienced teachers, who are also considered to be good teachers by their students. *These two teachers work respectively in Brazil and in France. We*

believe that they are potentially good to show us a variety of semiotic resources. This is a good opportunity to emphasize the similarities of experienced teachers resources. In the Brazilian case, the students of the selected teacher indicated this in answering a questionnaire after having studied with her. In the French case, the selected teacher is recognized as a good teacher by several generations of students, he is also involved in research in didactics and in teachers' education. In both cases, we selected a similar phase of teaching: when the teacher speaks to the whole class to deal with knowledge already introduced in the classroom, or during the correction of an activity. During this phase, the teacher focuses on explanations of important knowledge components. In other terms, following Kress (2010), we selected a same "genre" of speech to analyse the type and the sequence of modes that teacher arranges to make meaning.

In particular, they can show us how verbal and non-verbal modes operate when they make meaning of the content by describing (providing an account of a system, an object, or a phenomenon), defining (saying what a concept or process is) and explaining (clarifying concepts and processes) (Hansen-Thomas and Langman 2017).

As these teachers belong to different cultures – France and Brazil – and they are submitted to different norms and requirements, use different languages, we believe that if we succeed in showing their ways of using these modes, we can highlight some characteristics of the performance of good science teachers.

In doing so, we answered the following research questions: 1) How do teachers take things from the *milieu* and use them even by changing their original functions to make meaning? 2) What are the similarities and differences between the ways that these two good teachers use semiotic resources? In investigating these questions, we emphasise the ways the teachers use different resources to make meaning.

Methodology

We structure each teaching session in episodes. We consider an episode a unit of classroom discourse with well-defined borders (Mortimer et al. 2007). In this study, we consider the change of milieu and/or the change of content as border markers. To analyse the semiotic modes we selected episodes that show how the teachers use various semiotic modes.

For each of these episodes, we constructed a narrative (see narratives in supplementary materials), making a story with the sequence of actions and, if possible, the associated intentions. This narrative allows us to construct meaning of the entire episode. With this meaning as background, we identified the main semiotic resources used by the teachers, such as speech, gestures, gaze, proxemics, projection on the screen, the molecular model, writing on the board and artefacts used to make sense.

We analysed and classified the gestures used by the teachers in the episodes according to Kendon (2004) and identified catchments based on McNeill (2005).

The analyses were performed with the TRANSANA® software, which allows us to look simultaneously at videos and transcription.

To analyse the videos, we based our transcription on Kress (2010). We transcribed the words and the actions of each unit without a precise time correspondence (approximately 1/10s) (see transcripts in the supplementary materials). During these analyses, we came back to the video and sometimes looked at it frame by frame to put together all the observations when looking at the video with a regular speed at a given instant. Then, we could describe the teachers' actions. After this, we characterised the semiotic resources involved.

More specifically, the two cases studied came from an organic chemistry lecture in a graduate course at a public university in Brazil and a grade 10 physics class at a high school in France. Both teachers had more than ten years experience.

Teachers were video-recorded during several sessions. From these sessions we selected a lesson for each teacher where they present a part of the content that makes sense as a whole to the entire class. From the chosen lesson of the physics teacher, an episode of about 1 minute was selected. This episode represents a synthesis of activities implemented in the classroom with the students working in small groups. The teacher proposes a summary and presents a conceptual structure of the knowledge involved.

For the chemistry teacher, an episode about 1 minute long was selected. In this class, the episode is in an initial lesson in which the teacher reviews several aspects of the content students had already studied to highlight some important points the students normally misunderstand.

Data analyses and Results

We present the two different episodes to be analysed. The first episode comes from the physics class, and the second one is from the organic chemistry class.

Episode 1 (53 seconds) – the physics teacher

Context

The session from which this episode is extracted is a part of a teaching sequence of 12 video-recorded sessions starting at the beginning of the academic year (the 8th session). This sequence addresses the universe and involves the study of light from the perspective of the information given by the light coming from objects in the universe. This episode takes place in the middle of a session on the analysis of light for all grade-

10 students. This session is just after a laboratory work session, where the students used a spectroscope to decompose light from different sources and obtain a spectrum. The aim of the session is to restructure and generalise the knowledge involved in the previous experimental activities.

Just before the episode, the teacher has already projected the principle diagram of the dispersion of light on the white board (figure 1).

Figure 1 - The diagram of the dispersion of light projected on the white board.

Analysis

In this episode, the teacher explains the principle diagram. His explanation consists of placing this diagram in relation to the experiment carried out by the students. This explanation can be broken down into three parts.

Part 1: Relating the diagram with the experiment carried out by the students

A good example of resource-shaping occurs when the teacher points out the neon tube; it is primarily by gestures that the teacher brought the neon ceiling bulb to the classroom context. Normally, the ceiling bulb has a different function, that of lighting up a room. At this moment, the teacher brings this bulb to the context, considering it a specific light source for a physics experiment, giving a particular spectrum.

In what follows, the relationships between the experiments and the principle diagram is emphasised by a metaphoric “transportation” in the sense that the teacher brings the experiment, which is at this moment a thought experiment based on recalling, into the diagram projected on the whiteboard. Figure 2 shows an example of our detailed analysis for the transcription of speech and gestures (left column of the table) and for our interpretation. The combination of gestures and body movements associated

to the short speech: “you put the neon here” illustrates the relevance of considering an “ensemble” which makes meaning of the relationships between the experiment recalled by the teacher through his gestures and speech to the principle diagram on the whiteboard; here this ensemble, where gesture and body movement predominate, makes meaning of a fundamental component of physics, the relationships between theory and experiment.

Figure 2 A, B and C - Successive gestures and positioning when saying “ah the neon observes the light there you put the neon here”.

Figure 2D - The associated speech and gestures are given in the left column and our interpretation in terms of semiotic resource/ meaning making in the right column.

The following utterances emphasised the contact between the teacher and the students to the extent that he goes more succinctly on the idea of bringing the experiment to the diagram, but he gazes at the students while his gestures are directed toward the whiteboard.

In this part, the idea of relating the experiment already carried out by the students to the diagram is primarily introduced by the three successive modelling and action gestures of bringing each of the three elements of the experiment carried out in the previous session to the corresponding part of the diagram. Here, the whiteboard where the diagram is projected also plays a metaphoric role of the place of the theoretical knowledge, to the extent that this is the place where the teacher brings the material components of the experiment carried out before.

In this part, the diagram is present throughout the teacher’s presentation whatever his position. This diagram has all three theoretical elements present in the dispersion of light (the source of light, the prism and the screen), it also contains arrows indicating the path of light. The way each element is used constitutes an affordance to

the extent that it allows the teacher to distinguish and relate the theoretical elements (stable on the blackboard) and the material parts of the experiment. The teacher metaphorically brings each material element of the experiment to the diagram to the extent that there is a distance between the teacher's position and the whiteboard. In other words, the teacher constructs a milieu by making these ensembles of signs; from this milieu, the students can decipher the distinctions and the relations between the material objects of the experience and its model.

Part 2: Relating the diagram to the trajectory of light

In the second part the teacher's gestures do not emphasise the same ideas; whereas in the first part, the teacher's gestures are about the material objects, here they involve the trajectory of light, light dispersion and vision. Moreover, the teacher uses the writing mode, and, orally expands the example of sources of light to daylight. He writes these two words, and then adds the idea of the emission of light by saying it and emphasising the trajectory of light by a gesture, materialising it. For the spectroscope, there is no particular *gesture used by the teachers, who just writes*. On the contrary, a *complementary* oral, proxemics, and gesture production emphasises the idea that the eye can see the scattering. The teacher, gazing the students while turning his body toward them, says "your eye" and not eye, and he makes a rapid succession of gestures directed at the whiteboard, a representational action gesture for the act of seeing and a modelling gesture for what appears on the screen.

Here, to emphasize the main idea of the trajectory of light before and after scattering, the teacher uses a variety of modes including proxemics which emphasizes the space in which the phenomena of light travelling and scattering take place in relation to the position of the objects (source, prism, screen).

Part 3: Light scattering and vision

The third part addresses light scattering and what the eye can see and why. The speech gives the main ideas that are reinforced by many gestures in different ways and have several functions. Let us note that when the teacher says: “The eyes cannot see”, showing the line representing the light entering the prism, there is an apparent mismatch which emphasises the idea involved in all these utterances that before the prism, the eye cannot see the decomposition of the light. Moreover, following this utterance, the teacher shows the prism and says, “Your eye can see the colours that you have decomposed. Here, again, the teacher involves the students in the experiment, saying “your eye” and not “the eye”. Moreover, the gestures showing the triangle, which represent the prism, marks the rhythm of the prosody with hand movements making small circles over the triangle.

At the end of the utterance, the teacher underlines the verb “scatters” with a gesture of opening his arms (Fig. 3A-C).

Figure 3 A-C The teacher walks to the edge of the table and opens his arms (catchment gesture) for the scattering and says “behind the thing that scattered it [light]”.

Let us note that in the entire session, this type of gesture is used 8 times out of 12, and at the same time, a word meaning scatter (scatter, scattered, scattering) is uttered. Six times, he made the same gesture of opening his arms and twice of opening his hand. According to McNeil (2005), this gesture is a catchment; this catchment, associated with the phenomenon of scattering, develops a continuity of knowledge in the classroom (Nathan and Alibali 2011). This continuity of knowledge shapes the didactic contract, functioning as a way to develop the knowledge taught: this catchment can anchor a piece of knowledge like scattering, associating it to an action gesture of

opening arms. The last utterance of this part involves a move of the teacher, who goes down from the stage toward the first row of the students and says, “Activity 1 is this”, pointing to and looking at the blackboard (Fig. 4).

Figure 4 – Teacher points to the inscription on the whiteboard that represents the knowledge when he says: “then activity 1 is this”.

At this moment, the teacher keeps contact with students by moving closer to them while he shows and looks at the blackboard. It is a different way of keeping contact with students by gazing at them as he did before. This is a process already studied by Forest (2006), who calls it “giving way to the knowledge”. What is written on the whiteboard represents the knowledge, and the teacher indicates the preponderance of knowledge with regard to himself and shows that he is with all the students by being close to them (first row of the classroom). In other words, the whiteboard associated to the knowledge to be learnt becomes a new element of the milieu.

This part illustrates the place of knowledge in the relationship between the teacher and his students. The taught knowledge is not personalised by the teacher; it is external to him and simultaneously plays an important role in the teacher-student relationship. The teacher’s actions involve knowledge and are oriented to the students. These teachers’ actions are signs that inform us about the didactic contract. The teacher’s strategy is to present knowledge dissociated from him; it allows the students to discuss knowledge without involving the teacher as a person.

Gestures and proxemics

The three parts of the episode exemplify different ways in which gestures and proxemics bring meaning to oral and written discourse. In the first part, the gestures bring the main meaning, and the oral production goes along with them. The second part

shows the reverse; the gestures reinforce the meaning of the oral and written productions. The third part shows an intermediary situation. The importance of modelling gestures that represent the material objects of an experiment is also a characteristic of this extract. It is in line with a component of the teaching sequence that aims to distinguish theory/model and the material objects and events.

This episode shows the variety of semiotic resources combinations, very coherent focused on knowledge meaning. It also shows some of the relationships between the teacher's actions and the students. The teacher tries to involve the students in his presentation with gazes and the position of his body. The teacher's actions are clearly oriented toward the students and he does not personalise the knowledge. This knowledge is a transactional object between the students and the teacher.

Episode 2 (1 minute and 18 seconds) – The organic chemistry teacher

Context

The selected session is the first of a graduate course of organic chemistry, which lasts for 60 hours during the entire semester. In this lesson the teacher reviews different basic concepts and rules that students have already studied but tend to have difficulties according to the teacher's evaluation.

The teacher explains a rule and a counter-rule; students need to pay attention when they are using the Fischer projection. The Fischer projection is a two-dimensional representation of a three-dimensional organic molecule. The important rules to use this projection were explained by the teacher as follows: 1) Students cannot turn the represented molecule backwards, but 2) they can rotate the formula without removing it from the plan.

The teacher used different semiotic resources to demonstrate and to justify the rule, appealing to three types of representations: the Fischer projection and the skeletal formula, which were projected on the screen (Fig. 5), and the stick and ball model.

Figure 5 – The Fischer projection and the skeletal formula

Analysis

The creation of a third dimension

In this episode, the teacher tries to make explicit a rule and a counter-rule using different semiotic resources. The meaning in this episode is conferred primarily by the resources and the gestures that the teacher uses. The episode begins when she has finished the assembly of the molecule with the ball and stick model. Then, with the model in her hands, she moves toward the screen and superimposes the model on the formula that is projected on the screen, enacting an idiosyncratic deictic gesture (Fig. 6) with the model.

Figure 6 – The teacher enacts a deictic gesture with the ball and stick model superimposing it on the formula projected on the screen. At the same time she utters, “It is as if I arrive here and I do this here”.

This deictic gesture is very important because she simultaneously points to the spatial formula and highlights the model, comparing them. Superimposing gives the idea of three dimensions to the spatial formula projected on the screen. When she superimposes a shadow of a three-dimensional object in the two-dimensional formula on the screen, she uses the affordance of the model - that is three dimensional - to demonstrate that the formula represents a three-dimensional object in two dimensions. Her oral discourse only makes sense if it comes together with her gestures and with the two models. The

superimposition shows the sticks of one model and the traced lines of the other model fitting perfectly. It means that the traced lines that represent the chemical bonds on the spatial formula are the same as the sticks of the ball and stick model.

Establishing the counter-rule

She prepares to introduce the counter-rule by saying “you can never do “this here” oh” and moving toward the screen, getting close to the object of knowledge. Here she emphasizes the well-known students’ difficulties when using this rule - students tend to take the Fischer formula “out of the paper”, rotating it under 180° , which is forbidden. She searches for a place over which she can place her open hand prone to enact an action gesture. She makes this gesture when saying: “to get and to do like this”. The gesture is full of meaning and represents what the students cannot do when they are representing the spatial formula on the paper. It is accompanied by the sound of the hand beating on the screen and by the rhythm of her speech accompanying the gesture. She makes a pause in speech when gesturing, and this pause foregrounds the gesture.

She then re-enacts the same action gesture, beating her right hand four times over a sheet of paper on the table, emphasising the counter-rule (Fig. 7).

Figure 7 A– The teacher does an action gesture alternately beating her right hand prone and supine to establish the counter-rule, saying in the rhythm of the gesture “I can not re-beat”.

Figure 7 B - The associated speech and gestures are given in the left column and our interpretation in terms of semiotic resource/ meaning making in the right column.

Again, her gesture is accompanied by the sound of the hand beating on the table and by the rhythm of her speech accompanying the gesture. This time, the sound is louder than the previous one, and it is also produced during a pause in speech. Then, she re-enacts

the same gesture over the table during an oral pause. The action gesture during a pause comes to the foreground, acquiring meaning. Finally, she re-enacts the movement on the air once again while she speaks and looks at the students.

Establishing the rule

The first time she performs the gesture to specify the counter-rule, she anchors it to the Fischer projection on the screen. Then, she re-enacts the gesture over the table, using a sheet of paper as a support. This time, she is trying to explain to the students how to represent the same structure in their notebooks, so her action is kept at the same position as the students' when they draw the structure. At this moment, she gets a sheet of paper, positions it over the table and says, "Suppose I have a notebook here". At this moment, she constructs a new representation using an object, a sheet of paper (which represents the notebook), brought from the *milieu*, trying to reach common ground with the students. She enacts the gesture that represents the counter-rule over the sheet of paper. She does it again to represent the rule, as another example of resource shaping (Jewitt 2006), when she takes the same sheet of paper to demonstrate what should be done by the students (Fig. 8), that is, the rule, in the same way as we have just described.

Figure 8 A-B – The teacher makes an action gesture rotating her hand clockwise to establish the rule, saying "Suppose I have a notebook here".

We also observe that the teacher makes use of very different semiotic modes, including gesture, sound, rhythm and oral language, co-expressively, to make meaning. The teacher combines resources such as the spatial extent of a gesture, the pitch and loudness, the direction and length of a gaze, and proxemics. All these resources are

understood as parts of the resources for making meaning.

The teacher in this study combines the movement of the gesture, with the sound produced by her hand tapping over the table, and with her voice giving rhythm that can be perceived by the students. As stated by van Leeuwen (2005), the essence of rhythm is alternation between two states: an up and a down, a tense and a lax, a loud and a soft, a night and a day, an ebb and a flow. The alternation between two ‘opposite poles’ is so essential to human perception that we perceive it even when, ‘objectively’, it is not there.

Gaze and proxemics

The teacher also uses gaze and proxemics to include the students in her explanation. Considering proxemics is related to the distance between the speakers and the objects of knowledge, the teacher needs to be in a place where she can manage the three objects through which she is making meaning, e.g., the screen on the board, the overhead projector and the table where she picks up the components of the ball and stick model. This is in front of the class. The teacher compensates her physical distance to the students with her gaze, which is almost always directed toward the students, and with her body orientation, face-to-face with all the students.

Discussion

In the discussion we highlight the main characteristics of the two teachers in order to emphasize some aspects of how they make meaning of the knowledge at stake. In particular the following characteristics are considered important: their use of a variety of semiotic resources: the milieu, the gestures, the prosody and the gaze; the rhythm of their discourse, and the way they use catchment. Moreover each teacher uses semiotic modes differently, and we discuss how this difference is related to the content being

taught. We close the discussion showing that, in these lessons, the meaning emerges from simultaneous uses of diverse semiotic resources.

In this study, both teachers use artefacts that are incidentally present in the classroom for the meaning making process. Thus, they enrich the *milieu* with different semiotic resources and use the *milieu* in a particular way to make available signs that can make sense for the students. The teacher of organic chemistry takes a sheet of paper, and the teacher of physics takes a neon light to help the students to make meaning. In doing that, the sheet of paper becomes a “notebook” and the neon lamp becomes a source of light for a spectroscope. As stated by Jewitt (2006), sign-makers select, adapt and refashion meanings through the process of reading/interpretation. The theory of joint action in didactics brings up the idea that in the *milieu*, anything has the potential “to make sign” in relation to knowledge. The physics teacher points to the neon lamp not as a common object but as a semiotic resource, bringing a different meaning motivated by the context. At that moment, the teacher stresses the meaning of the lamp as a source of light to be decomposed into a light spectrum under the action of a spectroscope.

Moreover, according to our data, teachers can also create new signs from the resources available in the *milieu*. Considering themselves part of the *milieu*, they are prone to use their own resources (voice, gaze, gestures, proxemics, etc.), and many different artefacts present in this environment as signs to make meaning. By doing this, teachers also stimulate students with artefacts related to their everyday live.

An important characteristic of both teachers is their prosody and gaze. They commonly have pitch variations and stress syllables or complete words. This can be seen when the organic chemistry teacher is explaining the counter-rule. Van Leeuwen (2005) says that, in one context, everything may be stressed to convey excitement or, in

another, to make sure that not a word will be missed. On the other hand, the ways in which teachers often keep contact with students is by looking at them and having at least a part of their body directed toward them, moving toward them or standing close to them and speaking simultaneously.

Both teachers also repeat things that they consider important for students to remember. The organic chemistry teacher repeats the rule and the counter-rule six times. The physics teacher repeats the relationships between the principle diagram and the experimental settings twice in the episode.

The organic chemistry teacher applies each resource with a peculiarity to fix the rule and the counter-rule that she wants to convey to the students. This teacher, when demonstrating the counter-rule with the sheet of paper, uses two metaphorical images: the sheet of paper, representing a notebook, and her hand, representing the chemical formula. The physics teacher uses a diagram and associates the experiment metaphorically, and, when repeating it, he introduces writing, which emphasises the material elements of the experiment.

Both teachers use rhythm to emphasise the meaning they are trying to convey. The organic chemistry teacher accompanies her gesture with the sound of the hand beating on the table and with the rhythm of her speech accompanying the gesture. The physics teacher utters at the rhythm of the circles he makes with his hand emphasising the light decomposition by the prism. Van Leeuwen (2005, 181) states that “rhythm provides cohesion in texts and communicative events that unfold over time – conversations, oral storytelling, music, acting, dance, film and television, etc.” Rhythm is indispensable in fusing together the meanings expressed in and through different semiotic modes that enter into multimodal composition. It organises (and ‘vitalises’ and blows life into) communicative events (van Leeuwen 2005).

The catchments, according to Nathan and Alibali (2011), contribute to establishing intersubjectivity. The re-enactment via *catchments* resumes the original thought, such as anaphora, bringing the referent back to the discourse.

Thus, *catchments* convey a semantic association and contribute to discourse coherence. Meaning is made when our consciousness is directed toward these regularities. We found that teachers performed *catchments* in two different ways: anchored to the representation projected on the whiteboard or in the space shared with students. One example of catchment was enacted by the physics teacher, who pointed to and depicted the diagram on the whiteboard. This catchment acquired meaning anchored to the representation. That means that the representation is essential for the construction of meaning. The organic chemistry teacher enacted her counter-rule catchment in the space she shared with the students. In this case, the intersubjectivity became evident as the teacher metaphorically referred to the notebook and the formula through the gesture she made.

More globally, the way these teachers make knowledge meaning plays a role in the evolution of the didactic contract. The ensembles of signs introduce ways of sharing knowledge that are specific to the classrooms. These ways are very likely recurrent and then can become a classroom habit. They created specific strategies of science knowledge explanation thus developing the didactic contract of the classes.

The two teachers present specific characteristics, which are related to the content. The physics teacher emphasizes the relationships between the material situation and the concepts using gestures and proxemics, for example, when he metaphorically “transports” the experiment into the diagram projected on the whiteboard. The chemistry teacher, when she explains the rules and the counter rule, emphasizes the

relationships between three-dimensional molecular objects and their two dimension representations resorting to different semiotic modes such as action gestures and sound. We may suggest that their expertise allows them to orchestrate different semiotic modes to make an account of the deep conceptual meaning of their disciplines. These modes are simultaneously embodied (speech, gesture, proxemics and gaze) and disembodied (molecular model, neon lamp, paper sheet, diagram on the board etc.) and the coherence with which the teachers use them makes their practices remarkable.

In a similar way, Yeo and Gilbert (2014) conclude that a scientific explanation can be understood as a link of different modes of representation, such as linguistic, numerical, graphic and gestural. The importance of this recognition lies in that we should take the resources or semiotic modes as a whole to understand the meaning that a student or a teacher is trying to convey.

Yeo and Gilbert (2014) also conclude that the semiotic resources may play a role in relating abstract and material entities in the construction of an explanation by a student. Our analysis shows how the physics teacher relates the physical devices from the experiment to the principle diagram, maintaining the difference between the concrete and abstract aspects, and using multiple semiotic resources (speech, gesture and body motion) in doing this. These examples can be used to inform programs of professional development for teachers, as teachers often find it difficult to differentiate the two levels. Nevertheless future research should be done to better understand the role of these teachers' semiotic productions.

Final comments

Our theoretical framework, associating didactics theory and social semiotics, allows us to interpret teachers' production in terms of classroom practices. Both teachers use several semiotic resources for meaning making. What is remarkable is the

way those modes are orchestrated to make sense. Our use of types of gestures, prosody, proxemics, and, of course, words allows us to show the very frequent simultaneity of most of them. We think that the idea of a “multimodal ensemble” could help interpret how the teachers make meaning. These ensembles have a double function, meaning making of knowledge and communication.

The richness of these ensembles can characterise good teachers. Future studies are necessary to establish what could be considered good teaching from a multimodality perspective.

Both teachers are also considered good teachers. What have we observed in their practice that made them good teachers? We can see that both teachers have the capacity to improvise with different objects available in the environment, making meaning different from that of their current use; thus, they modify the milieu when producing ensembles of signs, which develop new types of relations between different pieces of knowledge. This can help students to understand more deeply the knowledge to be learnt. This improvisation is primarily focused on the development of the meaning of main points of the taught knowledge. These teachers also use embodied and disembodied modes in a coherent way to make meaning available to students. More generally, they extend the semiotic resources to deepen the conceptual meaning of their discipline. This goes in the same direction as studies on the relationships between teaching and learning that emphasises the importance of selecting few objectives and establishing links during teaching (Roth et al. 2011).

This type of study can contribute to making explicit teacher practices by interpreting all the modes used by them to construct knowledge meaning and keep contact with students. [Thus, it can be used to design resources for the professional development of teachers, which is an issue we are going to pursue in the future.](#)

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