

Supplementary Material of the manuscript: The role of multimodality and joint action theory in describing teaching practices: two cases studies with experienced teachers

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Appendix 1: Narratives

Narrative of the Physics teacher (episode 53 seconds long)

The teacher explains the relationships between the experimental devices of the activity carried out by the students in small groups in the previous session and the principle diagram, that is to say, the relationships between, on the one hand, the device using a neon tube, a spectroscope to disperse the light and a sheet of paper where the several colours of the light can be seen and, on the other hand, the corresponding principle diagram, with a screen that receives the dispersed light (figure 1).

The teacher's speech and gestures evoke the source of light, a neon tube, used in the activity; first, when facing the students while saying "neon tube ", he points out to the neon tube in the classroom, and then, he gestures with open arms to the representation of the source of light on the principle diagram drawn on the whiteboard. He continues saying "spectroscope" and simultaneously pointing with open arms to the triangle that represents the prism, i.e., the device dispersing the light; then, he says "eyes" and points at the line that represents the screen. His speech, gestures and movements, being in front of each elements of the drawn diagram on the whiteboard, make the experiment present with the same spatial structure as the diagram. He establishes relationships between the experimental device and its formal representation. Then, in a type of an intermediary conclusion, looking at the students, the teacher, with open arms, identifies the experiment conducted during the activity with the diagram ("Activity 1 is exactly this"). The teacher continues by placing a pencil on the table and comes back to the white board where he writes the three objects of the experiment in correspondence with those of the principle diagram. Here, this correspondence is repeated but in a different way. When he writes the last one, "the eye", associating it with the screen, he does not pause. He continues immediately to explain that the eye can see the colours of the obtained spectrum only if the light were decomposed, emphasising the role of the device dispersing the light, which he calls "thing", staying at a generalised level of the principle diagram; he associates his speech with deictic gesture towards the corresponding elements of the diagram. He thus justifies the place of the eye behind the apparatus that disperses the light. The sequential aspect of the experiment and of the principle diagram is clearly emphasised in space with the drawing and the teacher's deictic gestures and movements. To conclude, the teacher moves away from the whiteboard, looks at the classroom, points to the whiteboard and says, "Activity 1 is this".

Narrative of the Organic Chemistry teacher (episode 1 minute and 18 seconds long)

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 ball and stick model.

She intends to construct two main meanings: the rules (what can and cannot be conducted with the Fischer projection) and their justification. The rules are set up using the Fischer projection and the skeletal formula, projected side by side on the screen, and manipulating the ball and stick model to represent the same molecule that she had just finished assembling.

Her body is positioned toward the students, and for almost the entire time, she looked at the students even in the middle of the justifications, when she had to face back to refer to the formula projected on the screen.

Her speech alone is not enough to make sense. During all the episodes, she used 19 indexical expressions (e.g., this, that, here, this thing here). Those expressions only make sense when accompanied by the action and deictic gestures that refer to the artefacts she is manipulating and the projection she points to on the screen during her speech. In this sense, one cannot understand her speech if one cannot see her multimodal performance. Beyond modes, the professor brings to the context some artefacts during her actions.

The professor employed four different types of indexical words or expressions to refer to the rules and the molecules projected on the screen: 1) the indexical expression "this thing here," as a rule to refer to a concrete action (gesture) that she does, rotating clockwise or reversing; 2) the indexical word "this" to denote the rule as a whole, without referring to what can or cannot be done; 3) the indexical words "these", "those" and "this here" that she used to show the groups that are not on the same plane; 4) the words "here" and "it" to speak of what she can do with the ball and stick model. Consequently, to make meaning, she uses different types of semiotic resources and demonstrates a great fluidity to transpose from one to another.

She repeats the rule and counter-rule explanation six times: Four times, she utters, "I cannot reverse it", which refers to the counter-rule, and twice, she says, "I can do it here", which refers to the rule. Three times, when she clarifies the counter-rule ("I cannot reverse it"), her action is accompanied by a sound made by her hand beating over the screen (once) or the table (twice). Moreover, the third time the counter-rule is presented, the sound of her hand tapping the table is the only feature noticed during a verbal pause.

She utters the first sentence of this episode after having assembled, using the ball and stick model, the same molecule that was projected on the screen. This sentence used the expression "look" as a way to call the students' attention. At the end of the episode, she utters the expression "Is it clear for you?" which indicates that she had closed her intervention. In the episode that follows, she made a comment saying that reversion of the Fischer formula was a very common mistake students usually make when studying the subject.

Appendix 2: Speech Transcript, teacher's action and semiotic resource for each teacher

Appendix 2a: The physics teacher

| | Speech transcript | Teacher's action | Semiotic Resource /meaning making |
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| 1. | (0:28:45.0) alors dans l'activité 1 oui parce que on a observé bien sûr les néons (0:28:49.0) // (then in Activity 1 yes because of course we have observed the neon lights (0:28:49.0) //) | <i>Pr lifts his arm and hand and points out to neon light that is on the ceiling</i> | Deictic gesture towards the neon light on the ceiling Pr uses the neon of the classroom as a source of light of the experiment |
| 2. | ah les néons ils observent de la lumière voilà vous mettez le néon ici (0:28:52.4) // hop // (0:28:53.5) (ah the neon observes the light there you go you put the neon here // hop //(0:28:53.5)) | <i>Pr looks at the student until "voilà" then Pr points out with his arms and neutral hands opened, with a body movement towards the whiteboard, directed to the rectangle that represents the source of light. In his speech the deictic word « here » specifies the position that would have the neon, as a source of light, in the diagram</i> | Gaze at the students A combined - modelling (of the "neon tube" with his hands), action (bringing the neon bulb and put it) and deictic (shown where Pr puts the neon bulb in the diagram on the whiteboard) gesture Pr links the material light source to its representation in the diagram. Pr orients the students' toward knowledge on the whiteboard. |
| 3. | le spectroscope ici // (the spectroscope here (0:28:54.9) //) | <i>Pr indicates with his arms opened directed to the prism/spectroscope and simultaneously he looks at the students As for the « neon », Pr specifies the position that would have the spectroscope, in the diagram</i> | A combined–modelling (of the spectroscope), action (bringing the prism and put it) and deictic (where Pr inserts it into the diagram) gesture By gazing the students, Pr keeps contact with them Pr links the spectroscope to its representation in the diagram. Pr orients the students' toward knowledge on the whiteboard and keeps contact with them |
| 4. | et là il y a votre œil // (and your eyes are here (0:28:56) //) | <i>Pr represents the students' eye with his right hand prone while he looks at the</i> | A combined–representational modelling (of the eye), action |

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| | | <p><i>students</i> <i>As for the « neon », P specifies the position that would have students' eyes in the diagram with the half-bent fingers and open right hand</i></p> | <p>(bringing the eye and put it) and deictic (where Pr inserts it into the diagram, the line representing the screen) By gazing at the students, PR keeps contact with them</p> <p>Pr links the students' eyes to what can be seen at the screen Pr orients the students' toward knowledge on the whiteboard and keeps contact with them</p> |
| 5. | <p>d'accord l'activité 1 c'est exactement ça //</p> <p>(OK, activity 1 is exactly this (0:29:00) //)</p> | <p><i>Pr goes towards his table and looks at the students maintaining his arms apart beside his body and the hands supine.</i> <i>Pr opens his arms and goes back to the table</i> <i>Pr puts together the different elements introduced as parts of activity 1 (open arms palms up) and as a type of conclusion (coming back to the table)</i></p> | <p>Proxemics Body movement towards table (end of a part) and looks at the students Pragmatic performative gesture All these resources mean that Pr offers all things that have been done on the activity 1 to the students.</p> |
| 6. | <p>c'est le néon ou la lumière du jour le ciel (0:29:07) //</p> <p>(this is the neon or the day light the sky (0:29:07) //)</p> | <p><i>Pr takes a pen that is over the table and comes back to the whiteboard holding his pen</i></p> | <p>Proxemics body movement in direction of the object of learning</p> |
| 7. | <p>[no speech] (0:29:09.9)</p> | <p><i>Pr writes the words: neon and sky, under the rectangle "source of light" on the whiteboard</i></p> | <p>Writing "neon" and "sky"</p> |
| 8. | <p>ça émet de la lumière // (0:29:11) (this emits the light // (0:29:11))</p> | <p><i>Pr orients his arm towards the place of the whiteboard near the triangle representing the prism and quickly turns his head to the class</i></p> | <p>Action gesture that represents the light that is emitted by the neon – the gesture materializes the trajectory of light Looks at the students</p> |
| 9. | <p>là vous mettez le spectroscope // (0:29:13) (You put the spectroscope here //</p> | <p><i>Pr writes the word spectroscope on the whiteboard</i></p> | <p>Writing</p> |

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| | (0:29:13)) | | |
| 10. | et là vous mettez votre oeil j'ai mis un écran mais c'est // (0:29:18) (and you put your eyes here I've met the screen but it is // (0:29:18) | P writes the word eye | Writing |
| 11. | votre oeil voit (0:29:20) // (your eye sees (0:29:20) //) | <i>Pr turns to the students and enacts two successive gestures with the right hand while moving towards the students: an action gesture meaning 'seeing'; then a modeling gesture that represents the screen (on the space shared with students) during a verbal pause.</i> | Body movement (turning towards the students), A representational action gesture that means the eye perception; a representational modelling gesture (that means the screen) associated to a deictic towards the line representing the screen resumes the spectrum on this screen |
| 12. | la dispersion (0:29:22) // (the scattering (0:29:22) //) | Pr turns to the whiteboard and points out the line representing the screen with his right index and moves it down following the line representing the screen. | A deictic gesture that points out the screen; a representational action gesture with the right hand, extended index, moving down meaning light scattering on the screen; and body movement (turning towards the whiteboard) |
| 13. | alors voyez // (0:29:22.5) (now look // (0:29:22.5)) | Pr turns to the students and keeps his right hand pointing towards the line representing the screen on the whiteboard | A deictic gesture / body movement (turning towards the students) |
| 14. | votre œil il peut pas voir de quoi est composée la lumière par contre votre œil il peut voir les couleurs une fois que vous l'avez décomposée (0 :29 :28.6) // (your eyes cannot see what is the light composition on the other hand your eyes can see the colours after you decompose the light (0:29:28.6) //hup) | <i>Pr points out the line representing the light entering into the triangle representing the prism on the whiteboard with the right index.</i> <i>Pr enacts gestures in circles over the triangle (prism) projected on the whiteboard that emphasize and rhythm the utterance and points out the prism (spectroscope) on the whiteboard with the</i> | A deictic gesture with index, Modal and parsing pragmatic gestures (emphasis and rhythm), deictic with the open hand (showing the object used for light decomposition).. The prosody has a rhythm given by the small circles done by the right hand. |

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| | | <i>neutral hand open dorsal directed to the whiteboard when he utters 'décomposée', and he looks at the students. He gives rhythm with his hand movements and stressing syllables of the words</i> | |
| 15. | c'est pour ça qu'il faut le mettre derrière le truc qui a dispersé // (0:29:32) (this why you need to put the light behind the thing that scattered it // (0:29:32)) | <i>Pr moves away from the whiteboard and walks to the edge of the table and enacts a gesture with the right hand – that positions the source of light;</i> <i>Pr makes a gesture (opening arms) for the scattering</i> | body movement from the whiteboard to the corner of the classroom A modelling gesture with the right hand – that positions the source of light “behind” the spectroscope and an action gesture that means scattering Action gesture of opening arms representing the action of light dispersion. It is a catchment this gesture being previously done for scattering |
| 16. | c'est normal (0:29:34) (It's normal 0:29:34)) | <i>Pr comes to the edge of the first rank students</i> | Following of the body movement from the whiteboard to the corner of the classroom |
| 17. | bon (0:29:35)// (well (0:29:35)//) | <i>Pr closes his arm, and re-corks his pencil</i> | An action gesture (closing a part) |
| 18. | donc l'activité 1 c'est ça // (0:29:37) (Then activity 1 is this // (0:29:37)) | <i>Pr turns back to the whiteboard and points at it with the right hand neutral opened, while he utters “activité 1” and starts to return towards the whiteboard.</i> | A deictic gesture towards the whiteboard, and looks at the students: Pr gives way to knowledge |

Appendix 2b: The organic chemistry teacher

| | Speech transcripts | Teacher action | <i>Semiotic resource /meaning making</i> |
|----|--|---|---|
| 1. | (0:00:00) Ó // veja bem // quando eu faço isso aqui ó // vejam eu representei // é como se (look // when I do this here // look I've represented// it is as if) | <i>Pr moves toward the blackboard with the model in her hands</i> | Ball and stick model Projection on the screen Proxemics: directed to the object of learning. |
| 2. | (0:00:06) eu chegasse aqui e fizesse isso aqui // certo // (I arrive here and I'll do this here // OK?) | <i>Pr superimposes the model on the projected formula in between the uttered words: "Here" and "this here"</i> | Projection on the screen Ball and stick model Deictic gesture using the ball and stick model to superimpose the skeletal formula projected on the screen adding to it one more dimension. |
| 3. | aí porque que eu tô frisando isso// (so why am I emphasizing this?) | <i>Pr stops moving keeping herself near to the screen with the model positioned near her thorax, with her body oriented to the students looking at them</i> | Gaze and body orientation directed to the students and posture |
| 4. | porque quando você trabalha // com a projeção de Fischer // (because when you work with the Fischer projection) | <i>She is obliquely positioned, left to the blackboard, oriented to the students and looking at them she makes a gesture of emphasis and points up to the Fischer formula on the screen and slowly utters "work".</i> | Body orientation. Gaze: directed to the students. Gestures: modal pragmatic with emphasis. Deictic gesture with the index finger. |
| 5. | (0:00:17) a projeção de Fischer // (the Fischer projection) | <i>Pr enacts a gesture with the open right hand while uttering, faster this time: "Fischer projection"</i> | Modal pragmatic gesture: emphasizing the speech |
| 6. | jamais você vai poder fazer isto aqui ó // (you can never do "this here" oh) | <i>Pr directs herself toward the blackboard searching a place to put her open overstretched hand on it. She utters "aqui oh" followed by a small pause.</i> | Fischer projection. Preparation phase of an action gesture (pre-stroke hold). |
| 7. | pegar e fazer assim (1.1s) (to get and to do like this) | <i>Prof beats her right open hand on the screen with a sequential turning movement of palm, dorsal, palm, dorsal (re-beating). She finishes the enactment</i> | Action gesture to show the movement students cannot do with the formula. Prosody. Sound: beating of the hand on the screen. |

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| | | <i>in a pause of 1.1s that is accompanied by the sound of the hand beating on the screen. While uttering “pegar” (to get) she touches the screen with her right hand palm, so simultaneously she utters “fazer assim” (do like this) and turns dorsal hand to the screen. During a pause of 1.1s she repeats the movement.</i> | Rhythm: comes from the alternated hand movement and the sound of hand beating on the screen. Gaze |
| 8. | (0:00:24) porque que você não pode fazer // (Why can't you do?//) | <i>Pr performs gestures with the right open hand emphasizing her speech. She orients the body to the students and look at them.</i> | Modal pragmatic gesture emphasizing the speech. Posture Body orientation Gaze |
| 9. | não é a mesma coisa // (It's not the same thing) | <i>Pr superimposes the model on the formula (almost in the same position) that is projected on the screen.</i> | Stick and ball model. Fisher projection and skeletal formula |
| 10. | porque esses grupos aqui que aparentemente parecem estar no plano // essas ligações horizontais // (Because these groups here that seem as if they are on the plane // these horizontal bonds //) | <i>Pr points out the groups with the right open hand overstretched over the screen.</i> | Projection on the screen. Deictic gesture with the open hand showing chemical groups and bonds. |
| 11. | (0:00:32) elas não estão no plano // (they are not on the plane //) | <i>Pr performs a denying gesture, looking at the students.</i> | Denying emblematic gesture with the right extended index to sustains physically the idea presented by the speech. Gaze |
| 12. | Essas ligações hidrogênio OH // (these hydrogen OH bonds) | <i>Pr points out the hydrogen - OH bonds on the Fischer formula and utters “hidrogênio OH”.</i> | Projection on the screen. Deictic gesture with a ring hand shape, i. e., with the tips of thumb and index fingers in contact specifying H and OH on the formula. |
| 13. | Aqui essas estão pra frente pra frente e essa tá pra trás // (these here are forth forth this is back //) | <i>Pr points out both groups on the projected formula showing they are in opposite sides on the spatial structure. The hand shape is important because</i> | Projection on the screen. Deictic gesture with the thumb and index finger U-shaped allowing her to indicate H and OH simultaneously because |

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| | | <i>she wants to show H and OH at the same time. Gesture strokes coincide with the uttered words: “pra frente” (forth) and “pra frente” (forth). While uttering “e essa tá pra trás” (and this is back) she looks at the students.</i> | now she wants to show the spatial position of the bonds. Gaze |
| 14. | (0:00:40) então quando você faz isso aqui (so when you do this here) | <i>Pr moves her attention from the screen to the stick and ball model, orients her body to the students and turns backward the model she holds on her hands while she moves her thorax backwards in an impulse, as if she was opening space to permit the model turning.</i> | Action gesture: turning the model. Body orientation Gaze Proxemics |
| 15. | é completamente diferente não é no plano (it’s completely different it’s not on the plane) | <i>Pr she turns the model to the anterior position and enacts a beat with both hands holding the model emphasizing the phrase “não é no plano”(it’s not on the plane). While gesturing she is oriented to and looks at the students.</i> | Modal pragmatic gesture with both hands holding the model emphasizing the utterance. Body orientation. Gaze |
| 16. | Então qual é a forma que eu tenho pra trabalhar// (so what is the way to work with?//) | <i>Pr moves toward the table over which is the retro projector and enacts a gesture with the right hand semi-open on the thorax level and slowly she states “pra trabalhar” (to work with). Both resources emphasize the speech.</i> | Proxemics Pragmatic modal gesture giving emphasis. Prosody: reducing the speech speed. |
| 17. | (0:00:46) quando eu quero trabalhar com esses modelos eu tenho que fazer isto aqui ó (when I want to work with these models I need to do this here oh) | <i>Pr gets a sheet of paper that is beside the retro projector, and put it over the small table beside the retro projector.</i> | Action on her papers. Proxemics |
| 18. | vamos supor que estou aqui com o caderno (suppose we have a notebook here) | <i>She puts her right open hand prone (palm down) over the sheet of paper and beats on it noiselessly to point out the sheet of paper that represents the</i> | Sheet of paper that represents the notebook. Preparation phase of an action gesture (pre-stroke hold). |

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| | | <i>notebook while she utters “caderno” (notebook)</i> | |
| 19. | Eu só posso fazer isso aqui ó / (3s) (I can only make this here oh) / (3s) | <i>Pr turns the sheet of paper clockwise twice. She finishes the movement during a pause.</i> | Sheet of paper representing the notebook. Action gesture stroke phase. Prosody: pause. Gaze |
| 20. | não-POSSo-reba-ter // (I cannot re-beat) | <i>Pr performs the re-beating gesture over the same sheet of paper giving rhythm to the words with gesture, speaking the words conjoined with the hand beating on the table. The beat produces an audible sound.</i> | Sheet of paper representing the notebook. Action gesture. Sound: produced by hand beating on the table. Prosody: variation of intensity and spelling. Rhythm Gaze |
| 21. | (0:00:58) é óbvio que seu eu tiver com o MODELO NA MÃO // (it’s obvious that if I’m with the model in my hands) | <i>She moves away from the retro projector, looking at the students and utters: “modelo na mão” (model in my hands), she brings the model to the level of the chin in front of the body and enacts a gesture that emphasizes the discourse and shows the model.</i> | Stick and ball model Proxemics Gaze Prosody: increased intensity. Combined gesture – modal pragmatic and deictic - with the model to show it. |
| 22. | eu posso fazer o que eu quiser // (I’ll do what else I want) | <i>She turns the model backward and forward while she looks at the students.</i> | Stick and ball model Action gesture Gaze Prosody |
| 23. | a cheguei aqui e girei a ligação posso isso eu posso // (ah, I’ve gotten this here and turned the bond // I can // this I can do) | <i>She keeps holding the model at the thorax level and turns its bond. After she turns the model. Simultaneously, she looks at the students.</i> | Stick and ball model Action gesture Gaze |
| 24. | o que eu NÃO posso é // (What I can’t do is) | <i>She enacts a gesture with the right hand supine (palm up) and reduces the voice speed, and speaks louder. Together, this ensemble of resources gives emphasis to the speech. She keeps looking at the students.</i> | Modal pragmatic gesture emphasizing the utterance. She begins the next gestural phrase and holds on the preparation phase (pre-stroke hold). Prosody: higher intensity. Gaze |
| 25. | (0:01:10) fazer ISTO AQUI | <i>She performs a movement</i> | Sheet of paper |

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| | (1.1s) (... do this here) | <i>of hand turning that begins with the right hand supine (palm up) turns to palm down and she repeats it. She finishes the gesture during a verbal pause, in which the sound of hand beating on the table is audible.</i> | representing the notebook. Action gesture stroke phase showing the movement that cannot be done – catchment. Sound of hand beating on the table. Rhythm Prosody: intensity and pause. Gaze |
| 26. | no papel e achar que é a mesma coisa quando eu tiver analisando (on the paper thinking that is the same thing that happens when I'm analysing) | <i>She enacts the same movement once again, this time slower and noiseless, but it rhythmically accompanies her speech.</i> | Sheet of paper representing the notebook. Action gesture of re-beating reinforcing the idea. Rhythm Prosody Gaze |
| 27. | ái eu só faço isso aqui (1s??) (So, I only do this here) | <i>She resumes the movement of turning the sheet of paper clockwise and finishes it within a pause.</i> | Sheet of paper representing the notebook. Action gesture Prosody: pause Gaze |
| 28. | (0:01:18) Tá claro isso? / (Is it clear?) / | <i>She stops the movement before uttering this phrase and the gesture stands suspended.</i> | Action gesture is suspended in a post-stroke hold. Gaze |