# Part 7
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# MEANING MAKING WITH GESTURES AND STRUCTURAL REPRESENTATION MEDIA IN PRE-SERVICE TEACHING

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*Abstract:* This study is based on the sociocultural perspective (Vygotsky, 1962) in seeking to characterize the production of meaning in terms of different semiotic modes of communication and representation, which comprehend verbal, gestures and imagery discursive aspect. The research focus is on Chemistry Teaching, in which the chemical structural representation (CSR) is on evidence and the relationships among gestures, teaching purposes and the use of CSR media are the units of analysis for understanding the production of meanings in classroom situations. The potential of the categorical data analysis of this research is related to the software Nvivo that allowed the overlapping and crossing of gestural categories extracted from McNeill (2005), epistemic operations adapted of Silva & Mortimer (2010), and the media, chalkboard and projection screen. The quantitative data obtained illustrate the density and variety of gestures, the teaching proposal associated to the epistemic operations and the preferences for media of the chemical CSR, where time and the incidence of categories characterize the gesture and epistemic profiles of the teachers. The results presented in this work indicate implications for understanding the processes of meaning making in the classroom. Therefore, the episodic analysis associated to crossings categorical data suggest a hypothesis about gesture and epistemic patterns of the two teachers in function of preference for teaching media.

*Keywords:* gesture, epistemic operation, chemical structural representation.

## INTRODUCTION

Language influences the way thought is structured, since it is a social construction (Vygotsky, 1962). It is also a way of meaning making that is shared by communities (Lemke, 1990). Language is present in the semiotic modes as resources for meaning making through speech, writing, gestures, position, gaze and sound (Jewitt et al, 2001). These semiotic modes constitute a field called multimodality whose roots are based on the Systemic Functional Grammar of Michael Halliday and is also the basis for a field called social semiotcs (Halliday, 1994).

Understanding how semiotic resources perform an orchestration in the classroom has been an object of study that extend the analysis of discursive interactions, since it is not only the verbal mode that occurs the meaning making (Jewitt, 2005; Piccinini & Martins, 2005). The gestures are present in the communication as co-expression of speech (McNeil, 2005). The gestures are a visible action of the body that have specific functions in action units (Kendon, 2004).

The relationship between gesture and speech emerges from studies of psychology and linguistics. Based on an ethnographic approach, Roth and Lawless (2002) answered questions about why and how gestures might support the emergence of conceptual language. There are several gestural categorization, among them, McNeill (2005) include the following: deictic, beat, iconic and metaphorical. It was possible to employ them in the analysis of physics lessons, which considered the processes of electrification of material (Wolff-Michael Roth & Welzel, 2001), and of chemistry lessons about the constitution of molecules (Quadros & Mortimer, 2010). Adaptation of the four categories for teaching situations is a point to be

discussed in the context of chemical structural representations (CSR) (Giordan, Silva-Neto and Aizawa, 2015).

The present study is based on the sociocultural perspective (Vygotsky, 1962) in seeking to characterize the production of meaning in terms of other semiotic modes of communication and representation, besides the oral and written languages. The research focus is on Chemistry Teaching, in which the CSR is on evidence and the relationships among gestures, teaching purposes and the use of CSR media are the unit of analysis for understanding the production of meanings in classroom situations. From the relationships among the three categories, we raise a hypothesis about the occurrence of patterns for gestures in terms of the CSR media and teaching purposes. As a result of the analysis, different styles of teaching and modes of meaning making in the classroom are characterized.

For gesture analysis, four categories due to McNeill (2005) have been considered. The iconic and metaphorical gestures are classified as representational gestures, since the iconic gestures represent specific and concrete features of the molecular object displayed in the media, and metaphorical gestures refer to abstract aspects, namely generalizations produced with the use of CSR. Deictic gesture is related to a pointing movement to the SR and the beat gesture is used to emphasize the verbal speech of the teacher. Teaching purposes are categorized into epistemic operations (Silva & Mortimer, 2010) that the teacher performs. The media used to present the CSR in the classroom are chalkboard and chalk, projection and computer screens, spatial models of plastic or other materials.

The questions we intend to answer about the relationship between gestures, epistemic operations and media are: (1) which relationships do exist between the gestural performance of the teacher and the media? (2) how are characterized the styles of teaching from the co-occurrence of gestural categories, epistemic operations and media?

## METHODOLOGICAL DESIGN

The research data were collected by the video recording of chemistry lessons taught by two pre-service chemistry teachers of a public university in Brazil. Lessons have been designed in terms of didactic sequences based on the Topolical Model of Teaching, whose teaching structure is organized into levels (L). From the video recording, lesson have been segmented into episodes and discursive sequences that were transcribed (Figure 1).
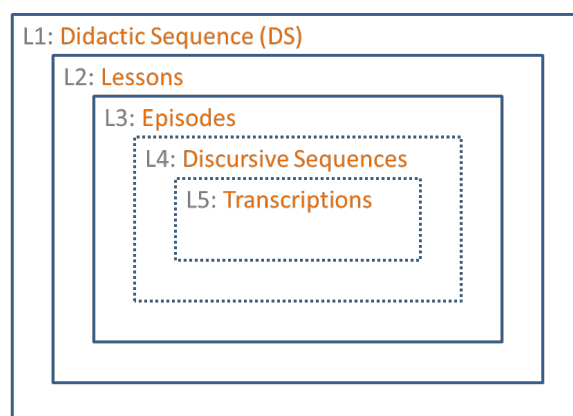


**Figure 1. Adaptation of the Topological Model of Education to characterize the video recording.**

Among the episodes of the two lessons, one of each pre-service teachers has been selected based on the presence of the CSR. The analysed episode of teacher P1 lasted 17min and 25s and the topic of didactic sequence was 'plastic bags'; the episode of teacher P2, about

'soaps and detergents', lasted 17min and 4s. The categorization was validated by peers. In this case, three researchers attributed the categories independently and then there were discussions on the agreements and disagreements. In Figure 2, the topology of levels for the two didactic sequences are represented by rectangles. In the inner rectangle, one can see the occurrence of the three categories of microgenetic analysis.
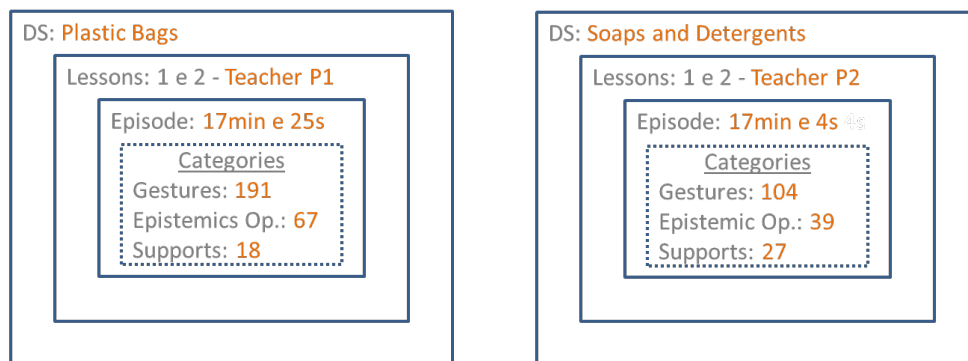


**Figure 2. Time lasting and occurrence of categories for both didactic sequences.**

The categorizations of both teaching episodes were performed in the computer software Nvivo 10. The software enables the organization and processing of data of hybrid research, both being a tool of systematic qualitative data and quantification of such data. In figure 3, we exemplify a diagram extracted from Nvivo showing a timeline of 4 minutes lasting and the co-occurrence epistemic (pink), gestural (blue) and media (green) categories.
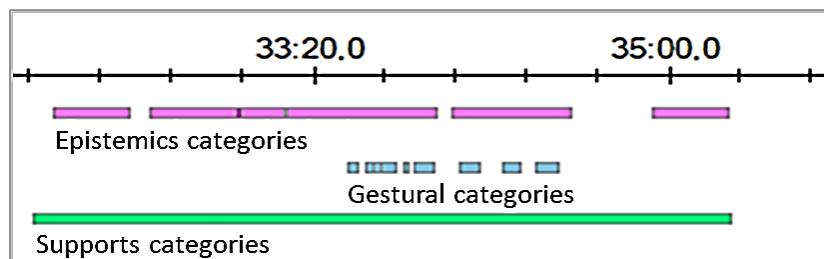


**Figure 3. Diagram of the Nvivo software illustrating the occurrence of epistemic, gestures and media categories.**

The data were compared using the cross table technique to investigate the patterns of gestures of the teachers in terms of the teaching purposes (epistemic operations) and the media used. Each category was confronted to the other in terms of the their co-occurrence. The cross table has been employed in two situations: (1) between two categories to study the gestural performance in different media of teaching and (2) to verify the occurrence of proportional relationship of iconicity and the degree of abstraction in different media. For the second case, we have fixed the medium (chalkboard and projection screen) and we have analysed the variation of gestural and epistemic categories, ie., the investigation occurs by crossing of three categories.

Therefore, the data were also analysed in terms of quantitative treatment of time (media) e and incidence of categories (cross table).


## RESULTS

The media of structural representations used to analyze the lessons of the teachers are shown in Figure 4, with chalkboard (a), projection screen (b), plastic models (c) and computer screen (d).
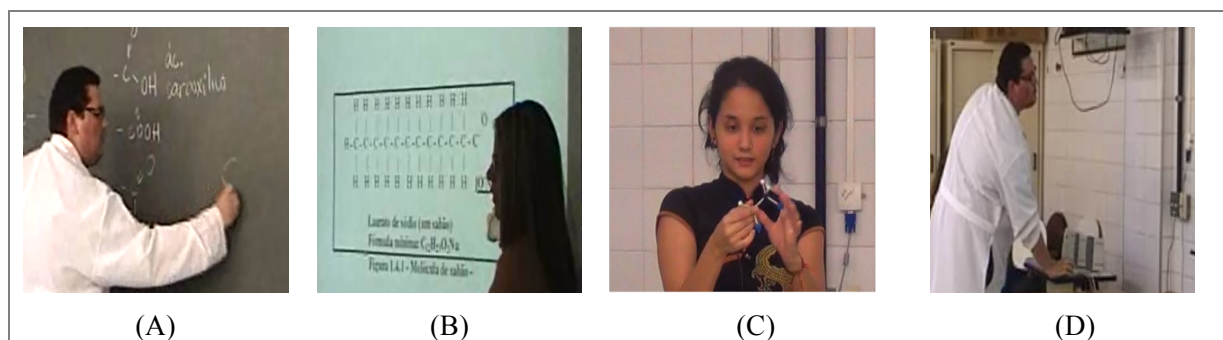
**Figure 4. Illustration of chalkboard (a), projection screen (b), plastic models (c), computer screen (d).**

The plastic model medium was not seen in two episodes and the computer screen was used only by P1 and therefore they are not carried out in the cross table analysis for both media. The chalkboard and projection screen were the most used media by the teachers. The data in Table 1 indicate that P1 remained most of the time at the projection screen, lasting 11 min and 42s (67%), moreover, there was also a greater amount of gestures (Table 2) at that medium (90%). In his turn, P2 uses both the projection screen (49%) as chalkboard (45%).

**Table 1. Frequency of use of chemical structural representation media.**

| Media | P1 | | P2 | |
|---|---|---|---|---|
| | Lasting (mm/ss) | % of the episode | Lasting (mm/ss) | % of the episode |
| Chalkboard | 02:38 | 15% | 07:40 | 45% |
| Computer screen | 01:06 | 6% | 00:00 | 0% |
| Projection screen | 11:42 | 67% | 08:20 | 49% |

The analysis of the gestures performed with different media has shown how the production of meaning occurred in the lessons of P1 because the chalkboard medium was used by the teacher to give information of molecular object that were not present in the projection screen illustrations. In addition, P1 made translations of RE present on the projection screen and gave other meanings to the concepts related to the nature of the molecular object.

The gestures were used to describe the dashed and filled wedges of the spatial structural representation of ethanol and impart to them senses of spatiality (Figure 5).
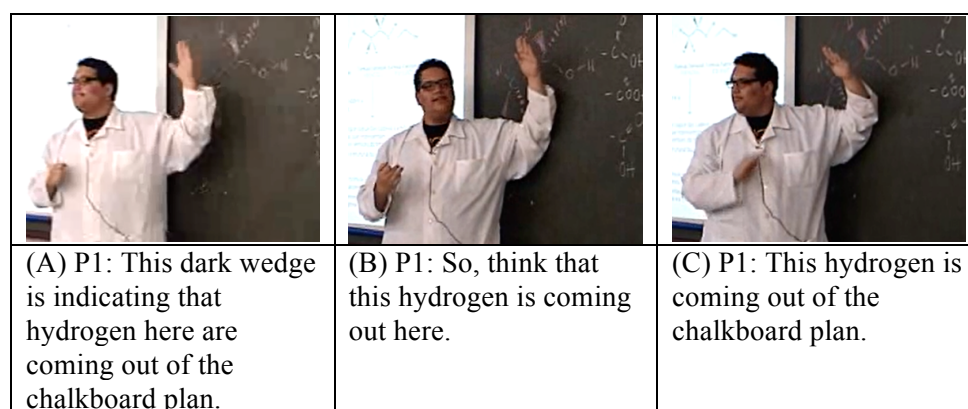


| (A) P1: This dark wedge is indicating that hydrogen here are coming out of the chalkboard plan. | (B) P1: So, think that this hydrogen is coming out here. | (C) P1: This hydrogen is coming out of the chalkboard plan. |
|---|---|---|

**Figure 5. Sequence of iconic gestures perfomed by P1 on the chalkboard.**

The data in Table 2 show that the greatest amount of gestures occur on the projection screen (90%), that is, the gestural performance of the teacher is featured on this medium as constituted by deictic gestures (63%) and beat (56%). However, the analysis of 8% of

gestures performed on the board by P1 (Table 2) indicated that 50% (8) of them are iconic gestures.

**Table 2. Relationship between categories of gestures and structural representation media.**

| Media / Gesture | P1 | | | P2 | |
|---|---|---|---|---|---|
| | Chalkboard (8%) | Projection screen (90%) | Computer screen (2%) | Chalkboard (56%) | Projection screen (44%) |
| Beat | 1 | 56 | 3 | 3 | 8 |
| Deitic | 6 | 63 | 0 | 31 | 24 |
| Iconic | 8 | 20 | 0 | 9 | 7 |
| Metaphoric | 1 | 31 | 0 | 23 | 13 |
| Total | 16 | 170 | 3 | 66 | 52 |

Therefore, when comparing the iconic gestures performed on the chalkboard with the epistemic operations, we found just one teaching purpose, during the course of the 8 gestures, the description of the molecular object (Table 3).

**Table 3. Overlapping frequency of gesture and epistemic categories at chalkboard medium for P1.**

| P1 – Chalkboard | | | |
|---|---|---|---|
| Epistemic op. / Gesture | Explanation | Molecular description | Exemplification |
| Beat | 1 | 1 | 0 |
| Deitic | 0 | 5 | 1 |
| Iconic | 0 | 8 | 0 |
| Metaphoric | 1 | 0 | 0 |

For P2, one observed a similar distribution of time between the two media (Table 1), the difference was only 40s (4%). By analysing Table 2 with the overlap of gestures and media, it was found that the frequency of gestures was slightly higher on the board, except the beat gestures whose overlay was three times at the projection screen (Figure 6).
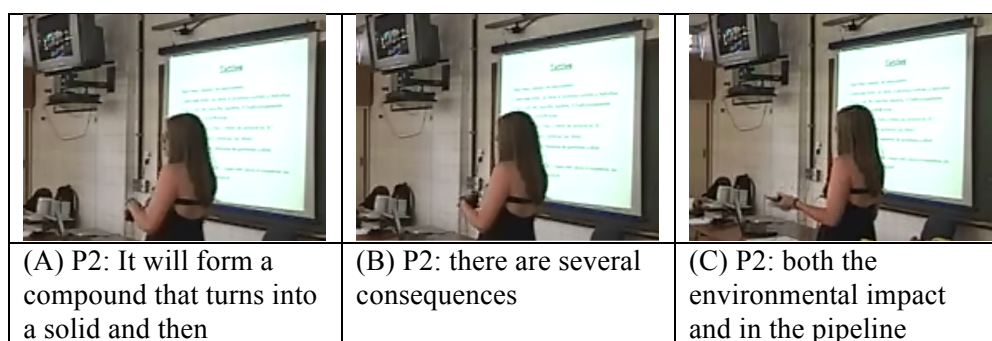


| (A) P2: It will form a compound that turns into a solid and then | (B) P2: there are several consequences | (C) P2: both the environmental impact and in the pipeline |

**Figure 6. Sequences of beat gestures performed by P2 on the projection screen.**

In situations of production of beat gestures at the projection screen, P2 held 3 beat gestures with the purpose of explaining the interaction of the molecular structure of soap with calcium and magnesium ions from hard water, and the formation of a solid compound (Figure 6A), in addition to indicate that there were consequences (Figure 6B) for the home pipeline system (Figure 6C).

In Table 4, one observes the co-occurrence of gestures and epistemic operations in the chalkboard medium, especially due to the beat gestures related to explanation (4), exemplification (3) and molecular description (1). Furthermore, the beat gesture corresponds to 50% of the epistemic operation exemplification (3).

Table 4. Overlapping frequency of gesture and epistemic categories at projection screen medium for P2.

| P2 – Projection screen | | | | |
|---|---|---|---|---|
| Epistemic op. <br><br> Gesture | Definition | Explanation | Molecular description | Exemplification |
| Beat | 0 | 4 | 1 | 3 |
| Deitic | 1 | 10 | 10 | 1 |
| Iconic | 0 | 4 | 1 | 2 |
| Metaphoric | 1 | 7 | 5 | 0 |

# DISCUSSION

In the teaching episode, P1 worked concepts related to the nature of the molecular object on which the analysis of categorical data indicates expanded gestural performance, ie, high density of gestures (191). The vast majority of gestures presented in table 2 (68%) refer to non-imagistic gestures, whose purpose was to indicate the molecular object (deictic gestures) or emphasize and give rhythm to the teacher's speech (beat gestures). The preferred medium wass the projection screen (67%), followed by chalkboard (15%) and computer screen (6%).

P2 used the CSR as a cultural tool to meaning making about the soap cleaning phenomenon, above all, emphasizing the interaction of particles. In the episode studied, she remade the meaning to CSR adding new information to molecular object. The gestural performance of P2 was more contained (104) that P1, which consisted primarily of deictic gestures and metaphoric gestures. In the projection screen, there was no presence of CSR and gestural movements emphasized and provided rhythm to the teacher's speech. At another point, P2 exemplified the soap cleaning processes and with a set of 3 beat gestures the teacher emphasized the word rubbing, moving his hands together as if rubbing something and also moving apart the hands to emphasize the movement of the soap in the aqueous medium. The beat gesture was also performed to indicate the transition of the teaching purpose, as the teacher indicated she would describe a molecular object and then she would explain a chemical reaction. Accordingly, the emphasis of the teacher is not on CSR presented in the medium, but it is on the purpose of explaining the chemical reaction of saponification through the molecular particles.

Thus, two teaching styles were observed whose characterization took place by means of gestural performance, teaching purposes and using of CSR media. P1 is a teacher whose expanded gestural performance consists mainly by deictic and beat gestures, which are performed mainly by his favorite medium (projection screen). However, one observes changes of the teacher gestural performance by modifying the teaching medium, as the frequency of iconic gestures is increased to 50% when P1 uses the chalkboard. In her turn, P2 has a constrained gestural performance with the recurrence of deictic or metaphorical gestures and she has no preference for teaching media, however, one observes the increase in the beat gestures when she modifies the teaching medium.

## FINAL REMARKS

The results presented in this study indicate implications for understanding the meaning making processes in the classroom from various semiotic modes of communication and representation (speech, gestures and images). The cross table technique for gestural, epistemic and medium categories allowed the characterization of teaching styles from the gestural performance studied in terms of density and gestural frequency, so that changes were

observed in the gestural performance of the teacher based on the teaching media employed to meaning making of the chemical concepts, that is, there are evidences that the change of the teaching medium alters the gestural performance of the teacher.

Thus, we suggest a hypothesis on the proportional relationship of gesture iconicity and the situations of use of less abstract epistemic operations, because the epistemic operation 'molecular description' refers to a CSR of the ethanol, which is a specific referent (Mortimer et al, 2005), therefore, less abstract, and the gestures performed highlight iconic elements of the CSR. However, in situations of generalization in which the CSR are treated in terms of class referents or abstract referents (Mortimer et al, 2005), there was an increase amount of metaphorical gestures. So, there are evidences that indicate the preference of P1 by metaphorical gestures combined with purposes related to more abstract epistemic operations, and to perform iconic gestures with less abstract epistemic operations.

It was noted that P1 had preference for the projection screen, as it was the medium that showed greater density and variability of gesture. However, to develop the lesson on the chalkboard, the gestures of P1 became more restrained and their variability indicated teaching purposes guided by the medium used. In her turn, P2 used equally both media and produced lower gesture density than P1, however, this decrease was due mainly to beat gestures, which may indicate that the teaching purposes of P2 were more related to the structural representation than to the verbal discourse. In this study, we found two types of teaching styles that were characterized by the use of gestures patterns for specific purposes, and that changed in accordance with the teaching medium used.

## ACKNOWLEDGMENTS

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