



Affordances and Constraints of Meaning-Making in Multimodal Science Classrooms

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Abstract

When explaining concepts in science classes, teachers make available to students a variety of communicative resources, both verbal and nonverbal. Nonverbal resources are especially useful when concepts are abstract or pertain to the microscopic world that is not immediately (visually, physically) available to students. Although the notion of teaching as a multimodal activity is well documented in the science education literature (e.g., [1], [2]), there still remains a gap in our understanding of how these multimodal resources are integrated in teaching, affording or constraining the construction of meanings [3]. In this study, we report on an analysis of teachers' use of multimodal resources while teaching the same scientific concept in different languages, in different sociocultural contexts, and to students from different linguistic and cultural backgrounds. Data was collected in two high school Biology classes, a grade 9 in an inner-city public school in a large Brazilian city, and a grade 11 in a suburban high school in a metropolitan Canadian city. Both teachers were female and native speakers of the specific language of instruction in each of the classes (i.e., Portuguese in Brazil, and English in Canada). Digital camcorders were used to capture the teacher, the students, and the board/screen in these classes. Data was analyzed with Transana ® software. Comparing the two contexts by analyzing the multimodal resources the two teachers utilized while teaching about synapses, as part of the unit on anatomy and physiology of the nervous system, the affordances and constraints of making meanings available to the audience became evident. Although the scientific concepts being taught were the same, the resources used and the way in which the explanation of the concepts unfolded during classes were starkly different in the two contexts. Understanding how the multimodal resources used in teaching science help or hinder the construction of meanings have implications for researchers, science teaching methods instructors, and teachers. A focus on how multimodal resources are integrated to create the conditions for meaning-making to occur will allow us to better equip future and practicing teachers with the pedagogical content knowledge needed to effectively communicate abstract, complex concepts to students.

Keywords: *Multimodality; Gestures; Classroom Communication; Biology Teaching*

1. Introduction: Multimodal Science Lectures

Lecturing is common strategy for teaching science at all grade levels. Good teachers are often said to be those who know not only the concepts, but also the most effective pedagogical strategies to teach those concepts, which includes knowing how to *explain* concepts most effectively; however, how teachers *perform* concepts in science classrooms [4] is an under-investigated topic in science education, particularly as it refers to the integration of verbal and nonverbal resources during teaching. Moreover, socio-cultural and linguistic backgrounds play an important role in how we communicate [5], yet to date we know little about how these aspects of communication are related to disciplinary discursive practices, both in terms of epistemological views of science and specific scientific content. This study is part of a larger research project that analyses the communicative and performative aspects of lectures delivered by Brazilian and Canadian secondary science teachers, focusing particularly on similarities and differences in performative aspects of teaching the same scientific concepts in different languages and socio-cultural backgrounds. The research question driving this study is, *how do communicative and performative aspects of teaching science in secondary schools vary between Brazilian and Canadian teachers when teaching the same scientific concepts?* In the particular study presented here, we focused on the types and abundance of multimodal meaning-making resources the teachers used when teaching about synapses, which are the nervous impulses that travel through nervous cells. We were particularly concerned with the ways in which each and all of these modalities combined afforded or constrained meaning-making opportunities, as these were made available by teachers during class.



2. Methods

This qualitative, cross-cultural study relied on micro video ethnographic methods to collect data in two grade 11 biology classes: in an inner-city public school in a large Brazilian state capital (approximately 1.5 million inhabitants), in a class with 25 mix-gendered students; and in a suburban public high school in a metropolitan Canadian city (approximately 750 thousand inhabitants), in a class with 28 mix-gendered students. In both classes, the teachers were experienced and data was collected in the second semester of the academic year. Multiple digital camcorders affixed on tripods were used to videotape the teacher and the students. Using Transana software, we performed a micro-analysis of data (frame-by-frame analysis), synchronizing speech and body movements, as well as other modalities available for meaning-making (e.g., projections on the screen, drawings and writing on the board, and three dimensional objects). At the macro-level, analysis focused on socio-cultural aspects of teaching science, such as issues related to disciplinary epistemological views, as well as pedagogical, discursive and interactional choices teachers make while teaching. The relevance of including such aspects of teaching into the analysis lies on the undeniable influence they have on the micro aspects of multimodal discourse, and consequently, on the outcomes of teaching in terms of meaning-making opportunities for students.

3. Findings and Discussion

The unit on Nervous System took a total of eight 75-minute lessons in the Canadian context (approximately 600 hours of instruction on this topic), and two 40-minute lessons in the Brazilian context. The Canadian teacher employed a variety of resources to teach the unit, including talking and gesturing; writing and drawing on the whiteboard, projecting students' notebook pages on the screen, with responses to fill-in-the-blank for students to copy down; projecting diagrams on the screen; projecting computer animations on the screen; simulating the impulse transmission with a set of fixed dominos; using experiments with a ruler (for testing students' reflexes); using her own body as reference for demonstrations; and an art project (when students built a nerve cell using spaghetti and marshmallows). The Brazilian teacher also used many resources, but in comparison to the Canadian teacher, these were significantly less diversified: she spoke and gestured; she projected text and diagrams on the screen; she wrote and drew on the whiteboard; and she demonstrated reflexes on her own body, also inviting students to perform some demonstrations with her in front of the class. In terms of discursive resources, both teachers used familiar, culturally relevant examples; analogies; mnemonic devices; humour, and repetition. Both teachers also made use of their own bodies as a general human body referent to point to body parts and to perform demonstrations (for reflexes) [6].

The structural resources available in the classrooms were also very different in the two contexts. In Brazil, the teacher moves from classroom to classroom, and students remain in the same classroom for the entire duration of the school day. Alternatively, in Canada the teachers have "home rooms," and the students move from classroom to classroom to attend the various classes they have during the school day. For this reason, the Canadian classroom had several objects related to science and biology, such as, for example, posters, three-dimensional models of the human body and its organs, glassware for laboratory practice, science textbooks, etc., which were permanently available in the space. In addition, the room was configured as a science laboratory, with wet benches (that is, work benches with sinks) along three of the four walls on the room. The room also had a permanent computer and projector & screen set, as well as a TV set (see Figure 1). The Brazilian classroom, on the other hand, served as a general grade 11 classroom for that particular group of students, in which all disciplines that comprise the core national (compulsory) grade 11 curriculum were taught. As such, it contained only the student, the white board and a TV set. The projector and the computer were brought in by the teacher, and as a result, the projector was set on one of the student desks, which considerably limited the size of the image projected (see Figure 2).

Regarding the affordances and constraints of the use of multimodalities during teaching, we highlight two findings from our analysis. First, because the students in the Brazilian context did not have any materials (textbooks or printed notes) to rely on, they needed to copy all the text and images from the slides projected on the screen during the lesson. This took away significant amount of time from the lesson, as the teacher needed to wait until students had finished copying it down. In addition, there was the potential for cognitive overload. Thus, the use of multimodalities in this particular situation, although important for the realization of meaning, could also be considered a constraint in the possibilities for meaning-making to occur, as students needed to choose between paying attention to the teacher and then copying down information or copying down information while the teacher was



explaining the concepts, which would inevitably divert their attention from the teacher's speech and gestures. In the Canadian context, as the topic was spread out among several lessons, the teacher could better organize the use of multimodal resources; moreover, the students had printed notes to work from, limiting the amount of information they needed to copy down during the lessons. Second, the slower pace, multiple lessons, and the diversity of multimodal resources used in the Canadian context allowed for the reinforcement of key ideas and concepts, within a conceptually developmental sequence that afforded multiple opportunities for meaning-making to take place. For example, for explaining how the nervous impulse travels through the cells, the teacher used diagrams, computer animations, a simulation with a fixed domino set, speech, and gestures/body movements. All of these resources were employed repeatedly and in complementarity to each other, as new terms and ideas were presented to students throughout the several lessons on this topic.



Figure 1. The Canadian classroom.

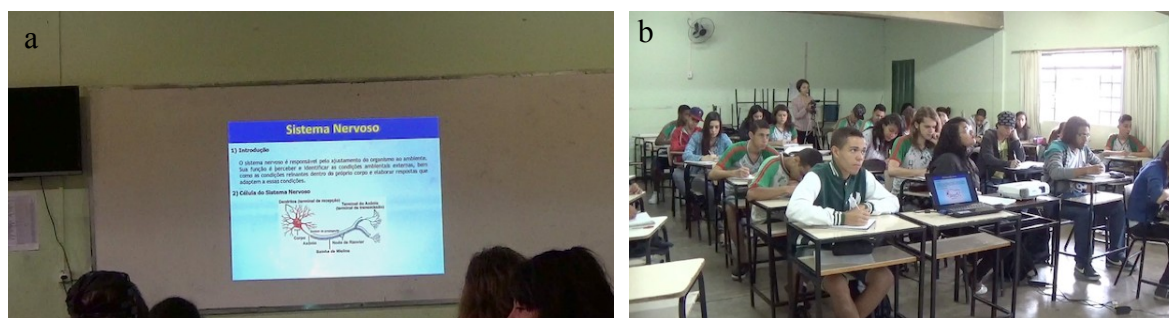


Figure 2. The Brazilian classroom. (a) The white board with a projected slide. (b) View from the other camera.

The type of analysis we conducted in this study affords the identification of important cues for what may be ordinarily referred to as effective explanations of concepts. In everyday interactions, people naturally use and interpret these cues, without even becoming aware of doing so [5]. However, if we are to teach science teacher candidates to be more effective communicators and to explain concepts more effectively, the exploration of these communicative and performative processes is a requisite first step to design strategies to teach these skills to future science teachers.

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