Multimodality of Explanation in Physics Class. Literacy engineering students

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Abstract

Qualitative study, aims to research about multimodal characteristics, of physics professors actions in the classroom. From a social, semiotic, rhetoric and argumentative perspective, we analyze the resources and communicative modes which work together with the verbal language and the functions each other of them, in the electromagnetism explanations. The results give us information about the role of different communicative modes to create scientific meaning and especially for to build own literacy in the engineering community; also give us information for improve the teachers communication skills for a specific audience.

Keywords: Multimodality in the classroom; Discourse analysis; Non verbal language; Physics Education; Engineering Education.

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Introduction

The classroom instruction is a multimodal process; it is done through speech, writing, gesture, image and particular configurations of space. From a multimodal social and semiotic perspective, we analysed the resources and communicative modes which are used together with the verbal language, and their functions in the explanations about electromagnetism of three lecturers in engineering classes. The results give us information about the role of different communicative modes to create scientific meaning and especially in the building the own literacy in the engineering community.

Specifically in engineering basic studies, how the semiotic modes acting in classrooms for the building meanings?. This study aims to inquire about multimodal teaching like identifier of a scientist community and describe multimodal discourse of physics professor in the classroom engineering, from point of view of the role of different communicative modes to create scientific meaning and their use like a complex teaching language in the engineering community. In previous research on discourse analysis of lecturers college physics, Rangel (2005, 2012), drew the emphasis that multimodality have in the teaching through of analysis of explanation and their action in the classroom, to afford images in two and three dimensions. This study will try to justify the theoretical basis and deep in this area of research.

Theoretical Framework

The multimodal language of sciences

We understand the process of teaching and learning and the creation of meanings, from the perspective of Vygotsky's sociocultural theory. In this theory is considered that learning is originated from social situations; and from the Social Semiotics general perspective, different semiotic systems are used and conventionalized in the communities to construct meaning through of interaction with others and the world, according to the needs of representation and communication of different social groups (Halliday, 1978). This learning process will depend on the contribution to the understanding that you may have previously of the new provided information, and therefore students contribute also to the creation of meaning.

All construction of meaning, any system or combined semiotic resources alone have been organize around three general semiotic functions that are representative, orientation and organization within a structure. When we create meanings of some reality, we construct simultaneously its presentation; it is oriented respect to others and thereby making an organized structure *textual* of related elements is create. We are agree with Lemke (1998) that concepts of science are not only verbal concepts, although they have verbal components. They are semiotic hybrids, simultaneously and essentially verbal, mathematical, graphical, and actional language. To do science, scientists speak, read and write science, as well make actions on material objects, and it is necessary to unite and combine in various canonical forms verbal speech, symbols, math, graphics, and motor actions to build the scientific explanations about the world. Lemke argues that we can't limit the teaching of scientific concepts to a single language or representation form, the teaching of physics goes beyond a display of mathematical equations. We are agree with Lemke when he said that scientific concepts are defined completely by using of verbal, visual, mathematical and actional language; where each mode or semiotic resource can be considered a communication channel that provides certain information but it is the interaction between the different modes which makes possible the construction of meaning as a whole. The discourse works by using code consisting of "a set of abstract principles governing the way in which texts are encoded by specific social groups, or within specific contexts, institutional" (Kress and Van Leeuwen, 2003: 159). Archer and Breuer (2015) studies states that to make students aware of these codes and to learn to use them through the interaction with others in relevant contexts are essential objectives of pedagogy in science classes: : talk, writing and act to favour the students developing their own knowledge and skills.

The representations with images show equal or greater difficulties than required by the verbal language interpretation. At university level, the use of images is very common within the science lecturer discourses. Otero (2004) in their studies on relevant aspects of the images of textbooks for Science Education initially states that "imaginary teaching" is full of myths and prejudices that influence teaching practice of science lecturers and educational materials design. However, recognizes that science involves speaking their language; part of a scientific culture is to talk and share be in the language of that culture. It is important that teachers are aware of the complex relationships between words, images and gestures that flow into their own dialogical talks in a science class and they have instruments to take into account the peculiarities of these languages and difficulties of the students to appropriate them. Manghi and Cordova (2011) in their research on literacy education from multimodal discourse analysis of the semiotic options used in teaching biology, find that teachers combine in an interleaved manner to the modal language to build meanings highlighting the semiotic potential of combination of face to face interaction and the slate. In fact In fact, the complete meaning is achieved by the combination of resources, which have complementary functions for both the representation of the spatial arrangement of some symbolism used,

as for the construction of taxonomies at different levels of abstraction.

Classroom discourse is very similar to the conference presentation, so it may be interesting for our research a study (Rowley-Jolivet, 2000) that analyses the oral presentation of scientific conferences in three fields (geology, medicine, physics) from visual semiotics perspective. There, the audience have to rely on their own technical visual knowledge's, for to understand each slide, their purposes, the relevant of the discourse, with the compositional knowledge, coding strategies, and interpretational knowledge may favour the audience comprehension when faced with the high density of visual data. As verbal communication, the images represent an understanding of the world acquired by the members of a particular group, and therefore the reader's meanings construction from a given image, it may depend heavily on the knowledge they share with the group. Reader of graphics has to filter the information through a social objective. This understanding the shared visual language of the participants allows them to read the "images" as a "text".

Perelman and Olbrecht-Tyteca (1958) introduces the "*presence*" notion. It is an essential element in the argumentation, based on the selection of concepts and how to present them in order to persuade and convince the student. Before to go to classroom, the teacher have to select, organize and classify content, and to select, consciously or not, a variety of rhetorical means to present the concepts to their students (the audience). Making this selection with a view to persuading the particular audience particular, the lecturers are using the presence from a methodological point of view. We give presence in the explanation when it cause an effect on the student: drawing their attention to the class, reminding the name, equation or mathematical variable, drawing a system, recreating a moving picture, setting in their mind, among others. This type of presence is related with the building of meanings and the multimodality in the classroom. In their research Kress, Jewitt, Ogborn and Tsatsarelis (2001) show us rhetorical functions of objects that mediate the action in the classroom, to give "presence" (make that it becomes more "real) at the conceptual entity, from which students can see new features and qualities that are useful in their conceptual building. Among several *presence*' resources they are a) showing the imaginary, where an identity is present to the student through the action with the body which acts as a rhetoric sign, and b) the demonstration using physical objects.

Methodology

The research is qualitative, based on case studies; it is an analytic and descriptive study, aiming to capture processes and their development. The experience is carried out in Venezuela, in the Engineering School at the University of Carabobo, taking like reference the discourse of three professors experienced in Electromagnetic Physics. Data was gathered through direct, non-participative, observation, supported by the video recording of classes and researcher's field notes. Through of a process transcription, a table that includes teaching speech, the drawings on the blackboard, the movements of the lecturer, and photographs it is constructed the table of data for the analysis. Data analysis is done from a multimodal perspective. The multimodal analysis looks for different elements of discourses and then a qualitative comparison between them is carried on and the accent is put on how the several modes work together to form a multimodal assembly.

In this paper, we will summarize analyses the modes that accompanying the verbal speech and the functions they perform in the explanations of lecturers to know the style of lecturers. Among the functions of the use of communication modes, we have: a) spatial representation function, creating spatial systems, ideas or concepts that need spatial approaches; b) introducing definitions of scientific terms, c) how the explanation is developing through the time, d) how the closing of explanation is done.

Example 1: Electrical field determination for continuous distribution of electrical charge.

The built of meanings and develop in competences in the explanation can be seen during the problem solving process, where the student integrates the various ideas presented in the classroom with their own. To think about improving the teaching in our context, it is necessary to be aware of how is in our particular context the teaching process in the Faculty of Engineering. In Figure 1, parts of the Laura explanation are shown, divided into four parts:

(a) 3D drawing system with colours in slate: Laura introduces the system while she goes drawing a disk on the blackboard. She writes over the system disk each characteristic (radius R, electrical charge Q, coordinate axes ...). She presents the differential of charge and its place in the system. She makes use of colours, deictic gests, adding traces and letters on the drawing process.

Then, she prepares students verbally announcing what she will perform: "we will use unit vectors and verify if there is symmetry".

(b) Drawing same system performing 2D plane view. To facilitate the understanding of the students, Laura makes a two-dimensional drawing, which represents the disk seen from above. She makes the connection between the two drawings; extrapolating the variables of the first drawing this new representation. And so she continues presenting variables, making them visible on the slate for facilitate the making meaning about area differential concept which is necessary for to apply the coulomb law.

(c) Visual analysis in three dimensional by Symmetry between vectors, making visible relations, comparison and operations using projections. Laura proceeds to show the analysis process by symmetry. Select two electrical charge differentials, symmetrical to each other. She draws both position and electrical field vectors for each case. She draws vector addition graphically to reach with many colours until electrical field due to these two electrical charges.

(d) Mathematical development. Finally, once those variables have been presented and graphically identified at the same time that the vectors involved in the system, Laura performs mathematical development expected until to obtain the mathematical expression that defines the value of electrical field. Taking into account the time spent, it is observed that the lecturer devotes two-thirds representation system to study, and at the end fluidly use the blackboard to solve mathematically.

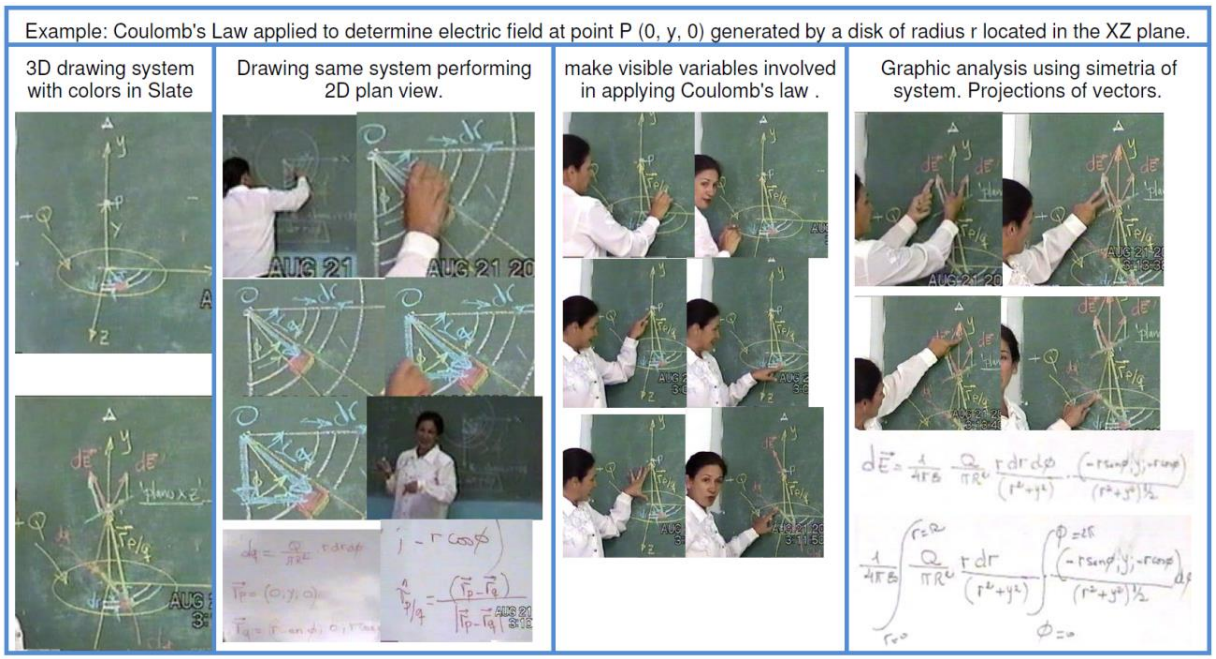

Figure 1. Multimodal discourse example with slate support: Coulomb´s Law applied to determinate electric field generated by a non-conductive disk

Example 2: Building the teaching sequence about Electric flux.

The Figure 2 shows a short of Pere explanations in Gauss Law. Pere began his explanation emphasizing: "FLUX, is a...". He introduces the flux concept graphically representing the system based in a plane surface drawing on the slate in tri-dimensional way. Next, Pere continues his story while he works on the slate, with drawing of same system with other sight and using of sequences in bi-dimensional representation with the plane in different positions.

Pere uses colours, gestures using the fingers like vectors in each one of graphs of the system for describing, comparing and differentiating variables such as surface, area vector, field and field line. He builds his story accompanying his speak with the multimodality, supported on the slate. Pere makes visible the story through a good drawing before start mathematical development.

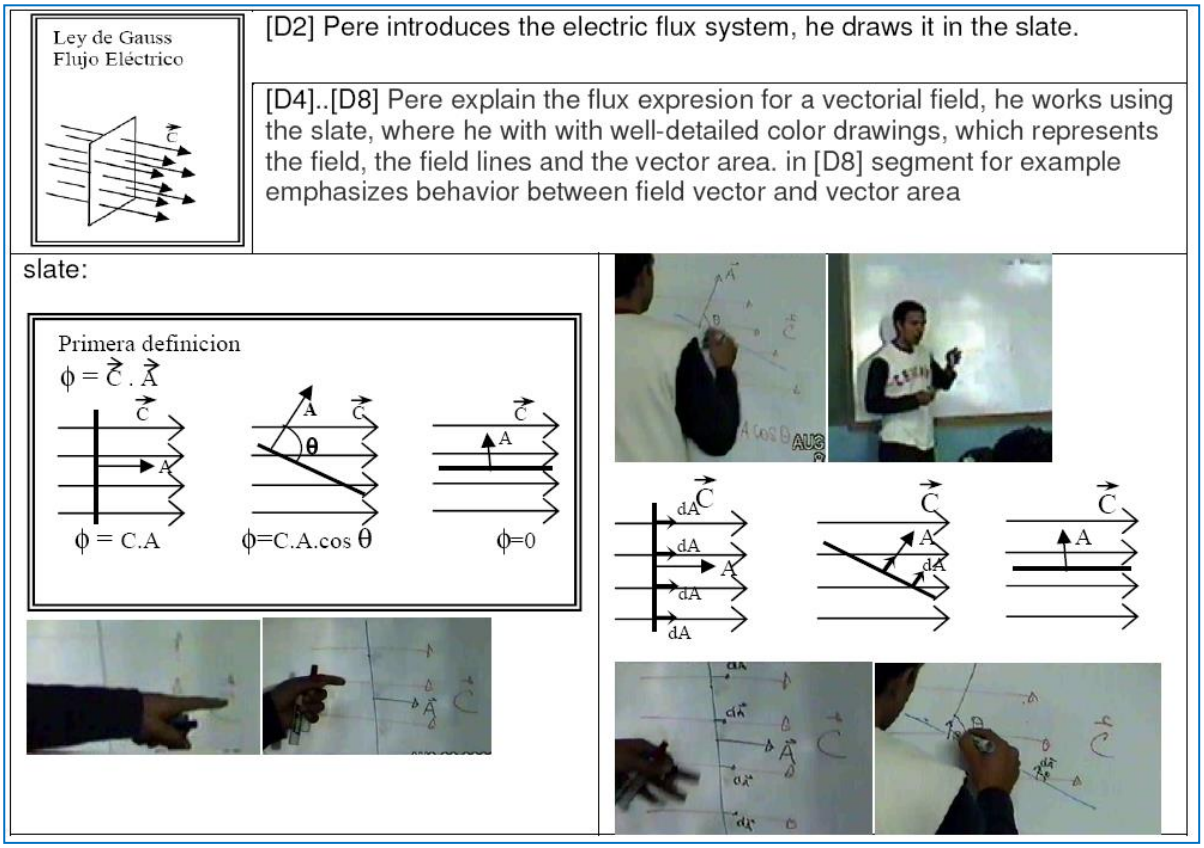

Figure 2. Electric Flux explanations, using physical objects supported on the blackboard.

Results

Professor discourse and the initial literacy of engineering student

The lecturer explanations gives the opportunity to engagement of students, practicing thus the ability to speak and understand spoken language. In the physics teaching, a technical vocabulary through language, the engineering student must appropriate as part of their training and professional identity. This is the importance of oral communication in the discourse of physics class. The lecturer's discourse is not only built through the transposition of the scientific knowledge to the specific educational context, but of verifying if the audience "receives" the ideas of his/her discourse. Is this continuous search for the agreement (*communion* with the audience), and the confirmation of the student's attention, what guides the professor's discourse, through feedback by the visual contact, or with the use of repetition and rhetorical question.

The physics teaching process includes an effort in the multimodal action in the classroom, to create physical systems from imaginary achieving in a high level presence. In this way, many multimodal resources are interacting between them and the students becomes immersed into them and so, being integrated in this imaginary system. The dynamic combination of multimodal resources in the action of lecturers enforces the presence of new concept to students, facilitating the meanings construction. Although, each lecturer had different ways to create the explanation about the same topic even using the same system, we noted an effort along of their explanations for keeping the student attention by means of they own way to use their voices, gazes, the inclination of their body, involving the students in the explanation that then, it will be considered as a whole by students. The representation modes used were: a) spatial representation, through recreation in scene, b) the use of the body and arms to give presence to the directionality of the electric field and surface vector, c) the spatial representation, using physical objects and imaginary objects, d) the representation on the slate, with colourful drawings, using objects physical too.

It is known that engineering student has to argue his explanations through mathematical development. However we wants to highlight that electromagnetic physics Lecturers with their multimodal action build their explanations oriented to a structured learning at the level of nonverbal language which describe how the engineering community communicate.

Communication supported on the board.

Professor strengthens its oral speech with the slate use. The slate is shown as essential to give the order of the concepts presented, and it is necessary for the work in detail and in an order on the board, giving *presence* to the premises, and maintaining adherence between auditorium and lecturer.

The board is used for: a) Write the name, nomenclature, the equation, the graphical representation, the units in which the object is

expressed, in order to present to the premises; as electric field, the electric flux vector surface. b) Illustrate a physical system. The first choice selected by lecturer is in order to illustrate, the lecturer accompanying his oral speech by choosing drawings and graphs done in the plane offered by the slate. c) Strengthening its three-dimensional view of the system, using the system of coordinate axes, and vector graphics. The use of colours, and performing graphical detail are very clearly observed. There is, a great effort by the lecturer, through of use of colours, repetitions, framing segments with fingers or underlining. Everything is done in order that the audience can: display the item in space, retaining a sequence of steps repeated continuously, and to understand the graphical representation of the variables presented, then they can be used as terms to be used in mathematical problem solving. d) To guide students in how to translate an idea, the most relevant concepts, which the lecturer takes into account through the symbolic language agreed, in how to solve a problem, how should raise the equations, how to assist the student in writing his examination or taking notes. e) Establishing procedural agreements in problem solving, implicitly. The lecturer does not say "this is how they have to analyze a system" but the student takes what the lecturer does, its procedures, as recommended; by the same authority that the lecturer is coated. f) To guide the order of discourse. It is noteworthy that, the order of discourse is consistent with the order carried on the board, which usually is divided into columns, and develops in an orderly manner writing from left to right starting at the top left, down sequentially in time.

Communication through gestures.

Gestures are absolutely necessary for professors' explanations. The coordinated hands along with arms achieves excellent use visual aids, especially where is required to direct the attention of the audience to some object that will help reinforce his speech, pointing, representing with physical or imaginary elements. And while the speech is made, it is recommended to be located so that the whole audience can see and taking care not to obstruct the vision of the students to their illustrations, representations or slate.

It is usually difficult to separate the spoken speech from the gestural. Among the observed features to this case, we have found: a) the use of hands to indicate a figure or graphic element, to give *presence* b) to represent the coordinate axes, c) to represent vectors d) when the teacher wants to strengthen the spatial aspects that has already been illustrated on the board, with the limitations offered by the slate plane; the teacher makes use of the arms, fingers, everything is taking special presence (in three dimensions) in the system being described.

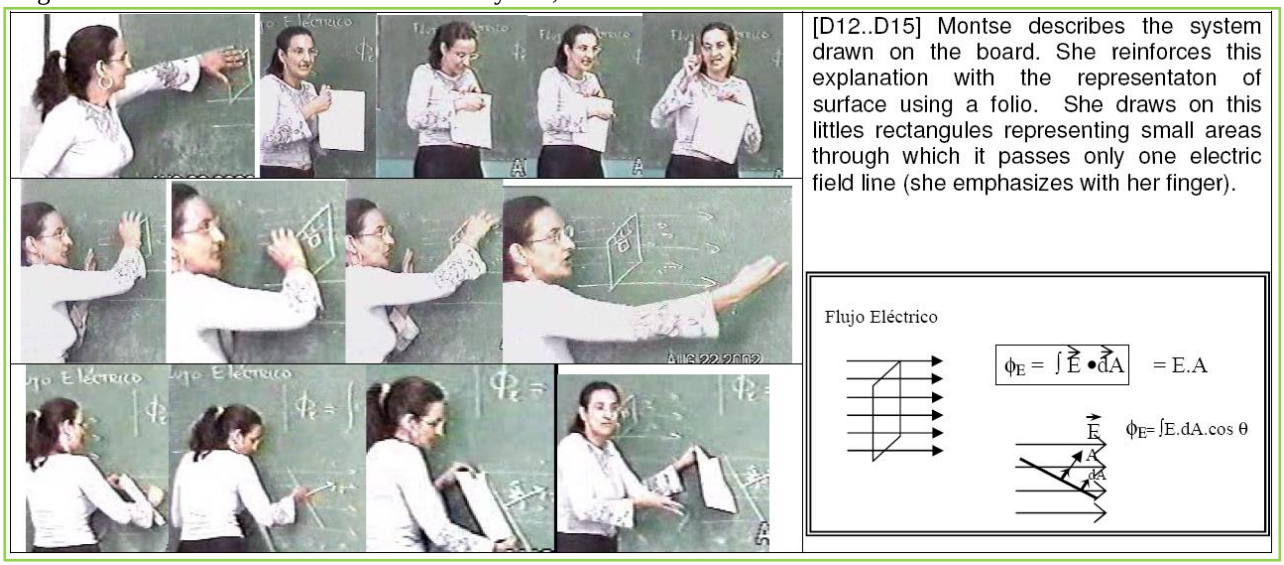

Figure 3. Electric Flux explanations, using physical objects on the slate.

Communication through physical representations

It is a mode of communication widely used in science classes, usually in practical or experiments activities; but generally it would consist in built the oral explanation by using also material objects as physical resource. In this experience we noted the constant use of elements such as draft folder, portfolio or classroom walls, all classroom space is involve into the story to reinforce the explanation; and to give spatial presence to the structure being described; creating analogies or connections as explained on the board.

In this mode of communication you can be attributed the following functions: a) increase the presence, b) Illustrate a physical system a phenomenon or experiment, c) reinforce three-dimensional vision system and d) strengthen the capacity of mental representation of the student.

Lecturers in their explanation, start drawing the system on the slate and also they make use representations with real or imaginary objects until

setting the necessary variables. Often, they use different views of same system and even do repeat times. The *Figure* 3, shows a short of Montse explanations about Gauss Law, in it is easy observe how the lecturer use the face, hands, body and objects actions to facilitate the meaning making for her students. So, he achieves to give to the object three dimensional attributes, using the spatial representation, through of using improvised objects. The communicative mode of representation using objects can be attributing the following functions to: a) increase the presence, b) Illustrate a physical system a phenomenon or experiment, c) reinforce three-dimensional vision system and d) strengthen the student capacities for mental representation of images.

Conclusions

Discourse analysis, provides insight into the domain of the Lecturer on multimodal communication resources and strengths they have in working together on the construction of meanings for the explanations and maintain the engagement and the adhesion of students to the proposals of the discourse. Research findings open new ways for deepening theories that contribute characterize the physics teaching and specifically for engineering lecturers'. Integrating knowledge about which elements and how they interact with each other to construct the multimodal discourse in classroom, in order to improve their praxis, taking into account the communicative capabilities for the building a discourse that could be effective for a specific audience, making meanings, and to develop abstraction capacities in the students. The dynamic of communion with the audience strengthens the construction of the knowledge and thus facilitates learning. A contribution of this research is the knowledge acquired by the researches through of analysis' process about the teaching process, contrasting it with the own one. The Lecturer makes use of all available resources in the classroom to help students to create three-dimensional images of systems that do not exist physically and that it will contribute to the engineer special vision, where the different forms of representation are more important than words.

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