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CONTRIBUTIONS OF TALK, GESTURE AND SALIENT ELEMENTS OF THE SETTING TO ANALYSE STUDENT'S IDEAS IN SCIENCE THROUGH VIDEO

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Abstract:

Over the past two decades, video analyses of science classroom have developed tools to describe, model and understand teaching and learning processes. Following the activity theory approach (Leontiev, 1978) using tools adapting from communication analysis (Givry & Roth, 2006), we propose to show what are the contributions of the interplay of talk, gestures and semiotic resources in the setting to analyze students' conceptualization. Our database consists of questionnaires, interviews and classroom video data and written worksheets of 14 students at the upper-secondary school level (Grade 10 [15-year-old students]) during a one-month teaching sequence about gas. We use Kronos software to code videos through several levels : Tasks (Macro), actions (Meso), meaning-making (Micro). Based on semiotic resources contained in language, we reconstruct in great detail all the ideas about gas expressed by students during the entire teaching sequence. Our results show (a) that we need to analyze simultaneously talk, gesture and salient element of the setting to reconstruct the meaning performed by student during communication acts. (b) how the interplay of talk, gestures and salient elements could be pertinent to describe the construction and the stabilization of the meaning of the word quantity performed by a student. However, some research already shows that prosodic features of speech (intensity, pitch, pitch contours) are further semiotic resources used in classroom conversations (Roth, 2005). Future research will show whether and how such additional resources further improve our unit of analysis called "idea". Furthermore, our results concern only a few students and cannot be extrapolated. We can considered it as assumptions which will be tested in future research.

Keywords: Science Learning, Students' ideas, Semiotic, Gestures, Video

BACKGROUND

Since the late 1970's, science education research have analyzed science learning in terms of student conceptions. There exists an enormous body of literature providing evidence for the existence of student conceptions that differ from the standard views of science (e.g., Pfundt & Duit, 2013). Different models have been proposed for describing the conceptual change students undergo (e.g., DiSessa, 2008) and some

studies identified conditions that would support the evolution of students' initial conceptions towards scientifically correct ones (e.g., Strike & Posner, 1992).

Over the past two decades, video analyses of science classroom have developed tools to describe, model and understand teaching and learning processes. Although these studies adopt different theoretical frameworks and methodologies, most of them analyzed videos through three levels (macro, meso and micro).

THEORETICAL FRAMEWORK

Our study: (a) adopts the activity theory approach (Leontiev, 1978) to analyse these levels and (b) uses tools adapting from communication analysis (Givry & Roth, 2006) to describe student's conceptual understanding in physics through the interplay of talk, gestures and semiotic resources in the setting.

Task, Activity-Action-Operation

Our theoretical framework adopts the activity theory approach (Leontiev, 1978) by using the distinction between the *task* (what people have to do) and the *activity* (what they really do). Each *activity* depends on a set of *actions*, which is composed by several *operations*. These definitions allow us to deal with teaching-learning situations through several levels. Concretely, we analyze: (1) the macro level based on the distribution of the tasks inside each lessons of the teaching sequence, (2) the meso level through the activity of teacher (to manage each task) and the activity of students (i.e. the actions to do each task), we focus on semiotic actions (writing and communicating) and (3) the micro level by reconstructing the meaning expressed by student's semiotic actions through specific operations.

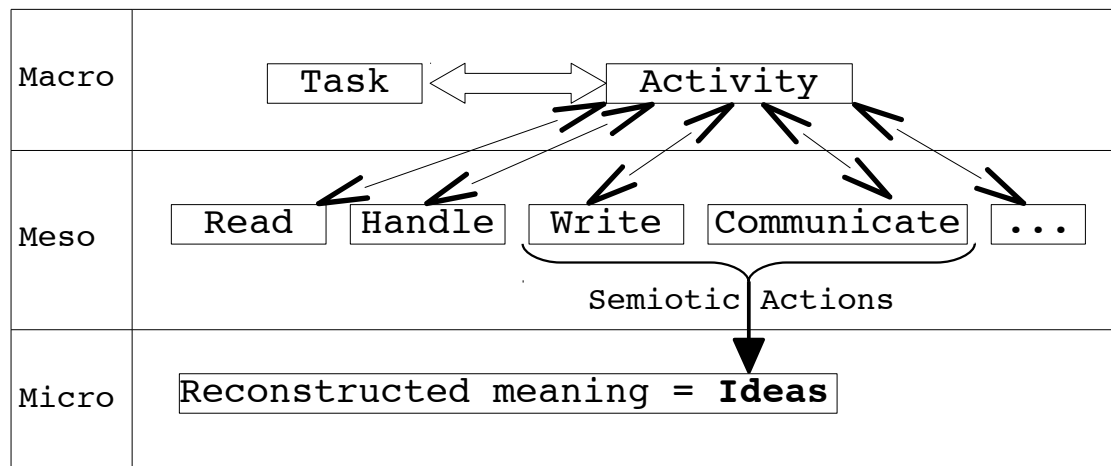


Figure 1: Link between levels of analysis (Macro, Meso, Micro) and Task, Semiotic Actions (writing, communicating) and ideas (meaning).

Ideas

Our study focuses on the actions which support student's communication. We define an "*idea*" as the meaning expressed by a person through semiotic resources contained in language in a specific context, and reconstructed by the researcher (figure 2).



Figure 2: Idea express the meaning through semiotic resources (talk, gesture, salient element, context)

This reconstruction of meaning requires to adopt student's points of view, without any judgement with regard to science point of view. Furthermore, we do not make any hypotheses of what happens in student's brain to minimise the risks of over-interpretation, because we have easy access to their discourse (e.g., Givry & Roth, 2006). Some previous researches (Givry & Roth, 2006; McNeil, 1985) show that participants or analysts cannot understand communicative acts without accessing the simultaneously produced gestures. We make the distinction between: "*gesture*" (semiotic hand movements), which appears during communication and "*manipulation*" (ergotic hand movements), which operates on objects during an experiment (Givry, 2003). The examples show that gestures in themselves do not lend themselves well to verbal rendering, in part because they are polysemic, in part because translation into words inherently belies the topological and dynamic nature of what is expressed. This suggests that talk and gesture are part of the same unit of analysis but cannot be reduced to one another. Consequently, researchers interested in students' conceptions ought to construct inscriptions forms that render what students communicate concurrently in the two different modes rather than stressing the verbal mode. In this way, talk and gesture *together* constitute a minimal psychological unit (Vygotsky, 1962). Each part contributes to the whole meaning but in different inherently contradictory ways: Gestures are global and synthetic, whereas talk uses segmentation and linearisation to form a hierarchy (McNeill, 1992). Furthermore, McNeil (1985) differentiated gestures into beat, deictic, iconic, and metaphoric gestures. In the present study, we follow recommendations to focus on deictic and symbolic gestures, including iconic and metaphoric gestures (Givry, 2003).

Recent research suggests, however, that the unit described before is not sufficient for describing situated communication—interaction participants actively use structures in the setting (e.g., grids, fields, and shape of a hopscotch field or the different images from a microscope displayed on a computer screen) as semiotic (meaning-making) resources in their communication (Goodwin, 2000; Roth, 2004). We need the interplay of talk, gesture and semiotic resources in the setting (called salient elements) to understand what is being communicated. Because these modalities convey the whole meaning but in different and irreducible ways. Furthermore, the perceptually salient element in the setting is a term understood as arising from "a dynamic, temporally, unfolding process accomplished through the ongoing rearrangement of structures, in the talk, participants' bodies, relevant artefacts, spaces, and features of the material surround that are the focus of the participants' scrutiny" (Goodwin, 2000, p. 1519). To summarise, we define an idea as a unit of analysis of all relevant semiotic (meaning-making) resources publicly made available by a speaker (through talk, gesture, salient elements of the setting) contained in communication in a specific context (Givry & Roth, 2006).

RESEARCH QUESTION

Our research question is what are the contributions of the interplay of talk, gesture and semiotic resources in the setting to describe student conceptual understanding in a teaching sequence about gas?

METHODOLOGY

Based on theoretical approaches about modeling activities (Tiberghien, 2000) a group called "Sesames" composed of physics teachers and researchers (including the first author) designed several teaching sequences. One of them is about gas and was designed to be taught over a one-month period (6 lessons) for French students at upper secondary school level (grade 10 [15-years-old students]) in agreement with the French official curriculum. In this study, we give pre and post questionnaires in seven classes of French public (state) schools. Two classes with the same teacher were studied in greater depth. To achieve a significant data sample, fourteen students from different achievement levels—based on the information obtained from the respective teachers—were asked, and agreed: (1) to be videotaped during the six lessons and give to us their written worksheets and (2) to answer pre/post interviews and questionnaires.

Our analysis is a case study of part of the fourteen students. It uses Kronos software to code videos through:

- Macro level: the tasks contained inside each lessons of the teaching sequence on gas,
- Meso level: Teacher and students' actions,
- Micro level: students' express specific words linked to the concepts of gas: pressure, volume, quantity, temperature, molecule...

We can replicate the Kronos analysis. However the list of words is not enough to have access to the meaning expressed by the students. Consequently, we need to do a

transcription (including talk, gesture, salient element) of (a) pre and post interviews and (b) teaching lessons. Based on semiotic resources contained in oral and written language, we reconstruct in great detail all the ideas about gas expressed by students during the entire teaching sequence and the interviews.

RESULTS

We present our results in terms of two assertions :

1. We need simultaneously talk, gesture and salient elements of the context to reconstruct the meaning express by student
2. the interplay of talk, gesture and salient element of the setting is pertinent to describe the construction and the stabilization of the meaning

1. Meaning conveys through talk, gesture, salient element of the context

To illustrate the role of the semiotic resources in the setting, we first analyze the transcription containing talk and gesture, and move to a second analysis of the same transcript to which relevant elements have been added. Based on this second analysis, we articulate the role of semiotic resources in the setting during students' interaction. In particular, we analyse the way students incorporate the semiotic resources in the setting as an integral part of their explanation. This can be seen in Episode 1 involving a student and the interviewer during a 30-minute interview. At the moment of the episode, the conversation pertained to the question was, "Where do the helium act into a balloon full of helium?"

Episode 1:

- 01 Interviewer: where the helium act into the balloon ?
02 Student E: It will go up thus that will be more [around here].
[deictic gesture]

Interviewer asks student "where do the helium act into the balloon" (turn 01). Student respond: "It will go up" (we analyze this sentence as the fact that the balloon full of helium goes up) "thus that will be more around here" and at the same time points to something (turn 02). Her talk and gestures do not give enough information to know where the helium is acting into the balloon. We need the interplay of talk, gesture and salient element of the setting to understand her explanation (figure 4).



Figure 4: Student E express through talk, deictic gesture and the salient element (balloon full of helium) the idea glossed as "helium act more into the top of a balloon full of helium"

Student says: "It will go up thus that will be more around here" (talk) while pointing (deictic gesture) with her hand in the direction of the top of the balloon (salient element in the setting). To understand the meaning, we need to simultaneously analyze the three modalities (talk, gestures, salient element in the setting), which can mean that helium act more into the top of the balloon and it could be the explanation of the fact that the balloon full of helium goes up. The physic point of view considers that helium acts everywhere into the balloon, and we need to compare the density of air and helium to understand why the balloon full of helium goes up.

We have more than 70 video extracts in our database, showing that we need to analyze simultaneously talk, gesture and salient element of the setting to understand the meaning performed by student during communication act.

2. Analysis construction and stabilization of meaning through talk, gesture, salient elements of the setting

We propose now to study the evolution of the meaning of the word "quantity" expressed by a student through the interplay of talk, gesture and salient elements of the context. In that aim, we ask a student (called A) : "what means the word quantity in a balloon full of air?" during an interview before (1) and after (2) the teaching on gas.

2.1. Meaning of quantity under construction before teaching

We propose to show how the interplay of talk gesture and salient element allows us to describe the construction of the meaning quantity for a student called A. Example 2 unfold after a question about the behaviors of three balloons: the first full of air, the second full of gas and the third full of helium. The student has to define what means the word quantity in a balloon full of air¹.

Episode 2:

01 Interviewer : in this balloon there is a specific quantity of air/ euh in your opinion what mea- what means for you the word quantity (1s)

02 Student : a specific quantity of air (?)

03 Interviewer : that's it voilà

04 Student A: well it depen- [symbolic gesture 1]/ quantity/ well it will depend of the object [deictic gesture 2]/ here for example in the balloon/ it will be [symbolic gesture 3]/ th::e [symbolic gesture 4]/ the quantity [beat gesture 5] it will be exactly what's [symbolic gesture 6]/ how to say that/ the the [symbolic gesture 7] the [symbolic gesture 8]/ the quantity euh [symbolic gesture 9]/ I don't know how to say that [symbolic gesture 10] (laugh)/the [symbolic gesture 11] all there are inside the balloon in fact [deictic + symbolic gesture 12]

05 Interviewer : yep

06 Student A : that will be the quantity [symbolic gesture 13] it will represent [symbolic gesture 14] the as the shape of the balloon [symbolic gesture 15]/

07 Interviewer : alright

08 Student A : the shape [symbolic gesture 16] and you have the volume [symbolic gesture 17]

09 Interviewer : Alright thus that is the volume isn't it (?)

10 Student A : yep/ the volume [symbolic gesture 18]

The interviewer asks what means the word quantity in a balloon full of air (turn 01). Student A repeat the words "quantity of air" from the interviewer's question (turn 2). Interviewer confirms (turn 03) and student A tries to give a definition with many hesitation and many gestures before saying "all there are inside the balloon in fact [deictic + symbolic gesture]"(turn 4)"that will be the quantity [symbolic gesture]"(turn 6) that we reconstruct as the idea a "*quantity is all there are inside the balloon*". Then, she specifies that "as the shape of the balloon [symbolic gesture]" (turn 06) that we consider as the idea b"*quantity is the shape of the balloon*". Student A speaks again about the shape and says "you have the volume [symbolic gesture]" (turn 08). Interviewer asks student A "that is the volume isn't it (?)" (turn 09), and she confirms

1 The second author, fluent in English and French, translated all transcriptions into equivalent English. Our transcription conventions are: (laughs) – transcriber's comments are enclosed in parentheses; [symbolic gesture] – square brackets indicate the kind of gesture; quantity[symbolic gesture] – underline indicate where speech and gestures overlap; – (n-dash) – indicates that an utterance or word stopped short before a completion was evident; (1.0) – time in tenth of a second; / – indicate a short pause about 0.1 seconds; : – colon indicates a lengthening of a phoneme by about 0.1 seconds.

that yep/ the volume [symbolic gesture] (turn 10), that we interpret as the idea c "*quantity is the volume*".

Our analysis of the example 2 shows that talk and gesture are pertinent to describe how the meaning of the term "quantity" is under construction by student A. Indeed, during this short extract, we reconstruct 3 different ideas based on the meaning expressed by student A with her talk and 19 gestures and 2 salient element of the setting (showing by the two deictic gestures). These gestures are very different in terms of : (a) type (symbolic, deictic, beat), (b) movements (vertically, horizontally, circle...) and (c) the number of hands (some gestures is performed by one hand and others by two). Furthermore, student A express 3 different meanings : a. "*quantity is all there are inside the balloon*", b. "*quantity is the shape of the balloon*" and c. "*quantity is the volume*". The first (a) is close to the physics point of view, whereas the others are very far. We consider the fact of using during the same explanation many meanings and many gestures with different types, movements... as a good indicator of student's construction of the meaning of the term "quantity". In others words the meaning of this term is not stabilized in the situation of a balloon full of air.

2.2. *Stabilization of the meaning of quantity after teaching*

We propose to show the stabilization of the meaning of the word quantity during the same question of the interview after a one month teaching on gas. Example 3 unfold during the interview after teaching during the question about the behaviors of three balloons: the first full of air, the second full of gas and the third full of helium. The student have to define what means the word quantity in a balloon full of air.

Example 3

- 01 Interviewer: into the balloon of helium, there is a quantity, could you define what do you mean by the word quantity
- 02 Student A: a specific quantity of air/ eu:::h/ the quantity (?)
- 03 Interviewer : yes
- 04 Student A : well the number of molecules

Interviewer ask to student A "what do you mean by the word quantity" (turn 01). Student A repeats twice the term quantity like to be sure that she understand correctly the question (turn 02). Then she define the term quantity by "the number of molecules"(turn 04) glossed as the idea d "*quantity is the number of molecules*".

This extract shows that student A defines the term quantity as the number of molecules without using gesture or salient element of the setting during the interview after the teaching sequence of gas. The fact that she uses only talk without other semiotic resource during this interview shows an important evolution in regard to the definition given during the interview before using 3 different meanings, 19 gestures and 2 salient elements of the context. The interplay of talk gesture and salient element allows us to describe finely the ongoing construction of the meanings of "quantity" before the teaching and to consider the stabilization of the meaning (quantity is the number of molecules) after the lessons only in the situation of a balloon full of air. It

is important to specify that in regard to student A the stabilization of the meaning of quantity is only in this situation. We need to find if : (1) student A uses the same meaning to answer other questions during the interview or (2) she uses this meaning in other contexts (class lesson, questionnaire...). In our data, student A does not use this meaning in other questions of the interview, but she uses this meaning in some situations of the end of the teaching sequence of gas. That allows us to consider that this meaning is stabilized in more than one situation.

CONCLUSION

Our results re-enforce the need to use video analysis in science education research, in our case to provide a better understanding of students ideas about gas. They show (a) that we need to analyze simultaneously talk, gesture and salient element of the setting to reconstruct the meaning performed by student during communication act. (b) how the interplay of talk, gestures and salient elements could be pertinent to describe the construction and the stabilization of the meaning of the word quantity.

Our study is based on talk, gesture and salient elements. However, some research already show that prosodic features of speech (intensity, pitch, pitch contours) are further semiotic resources used in classroom conversations (Roth, 2005). Future research will show whether and how such additional resources further improve our unit of analysis called "idea". Furthermore, our results concern only a few students during the specific teaching sequence about gas. They cannot be extrapolated to other students or in other teaching sequences. However, they can be: (a) compared with results of previous studies and (b) considered as assumptions which will be tested in new studies.

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