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Analysing verbal interaction between teacher and pupils on tenth grade physics classroom.

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INTRODUCTION

Students misconceptions have been widely investigated. Research has shown how robust they are, outliving teaching that contradicts them. According to Posner's theory of conceptual change (1982), teachers can facilitate the processes of accommodation. This may be achieved: a) by confronting students' existing concepts against facts; b) by pointing out contradictions among points of view; c) by asking for consistency; d) by making a given scientific theory intelligible, plausible and fruitfull.

Classroom research has given empirical support to Posner's theory: regulation and accommodation processes are stimulated by teaching strategies that stress cognitive conflicts and socialization of ideas in small groups or in the whole class (Nussbaum & Novick 1981, Thorley & Treagust 1987, Rogan 1988 and Silva 1990).

Despite positive results, the available reports do not make clear how the teacher interacts with the class. What kind of questions does he ask? How does he guide the flow of dialogue in order to improve discussion? Thinking, inquiring, discovering better explanations are not common activities in our regular classrooms. How do students react to cognitive conflicts? Public debate may be seen as a threatening situation or as a waste of time. McCasland (1987) observed more resistance to conceptual curricula among "bright" pupils than among average and lower track students, usually considered "less able" or less interested in school. Non-advanced classes seemed more confortable to participate. "Good" students felt intimidated: they were afraid not to give the "right answer".

Studying dialogues, Hewson & Thorley (1989) found that some questions were particularly stimulating. They were of metacognitive nature, asking for comments, feelings or attitudes about a given statement: "What do you think of that idea?"; "Does it seem strange to you? Why?"; " How can you convince me that you are right?"...They concluded that "having students

monitor the intelligibility, plausibility and fruitfullness of their and other's conceptions would seem to be a promising avenue to effective conceptual change instruction" (page 551).

The analysis of classroom discourse may illuminate the processes related to social construction of knowledge. It may also reveal which teaching strategies are more frequent, more effective and more difficult to implement. Some practices such as elicitation of pupils ideas, collaborative learning methods and practical work have been considered valuable and easy to apply. On the other hand, discussion sessions have been rare. Teachers recognized that learners needed help to restructure their knowledge, but this was the more difficult activity they had to perform (Constable & Long, 1991).

The power and quality of classroom debate requires more than simply selecting and applying sucessfull teaching strategies. Teacher's ideological and epistemological conceptions may be a hindrance to promote intellectual independence. There are teachers who monopolise thinking. Some of them do not allow the exploration of different perspectives. Others try to persuade and indoctrinate (Young 1981, Gil 1986, Brickhouse 1989, Geddis 1991 and Gil & Carvalho 1992). Positivist attitudes may be the source of conflict between teachers efforts to give students opportunities to develop their own understandings and his traditional efforts to offer information (Anderson & Belt 1987 and Glasson & Lalik 1993).

Not only students but also teachers have misconceptions. They are related to the nature of teaching, learning, science and its relationships to society. This kind of knowledge affects teachers' practices, weakening or neutralizing intended projects of innovation, deviating or undermining classroom overt interaction (Carvalho, 1989). This hidden side cannot be ignored when we intend to examine classroom discourse.

This paper will take Posner's pedagogical suggestions as parameters to classify and interpret verbal interaction between teacher and pupils. The purpose is to investigate what aspects of the model were more frequent in our samples and which ones were the most difficult to put into practice.

METHOD

We have carried out two studies.

In the first one we have compared different styles to conduct classroom discussions and the responses they have arisen among students.

In the second study we have chosen one class and selected sessions from the beginning, the middle and the end of the course. We looked for conceptual changes, describing the verbal contexts in which they have taken place.

To compare teachers styles, we selected samples from videotapes of two tenth grade classrooms, belonging to two different schools, where a course on "heat and temperature"has been carried out. The program was developed during one semester, three classes a week. MARY was the teacher in a private school. She was a newcomer and hardly knew her pupils.They belonged to upper-middle-class and attended school during morning. JOHN taught in a public school. He was respected among his peers and admired by students. They were from lower-middle class homes, worked during the whole day and attended classes in the evening.

Both teachers have planned the course together. But their interaction with students were different. To analyse such a difference in teaching practices we chose two sessions from each teacher. The meetings were about the same topics.

In the first sessions people were engaged in a discussion about "what actually goes on inside an object as it is heated". It lasted for 45 minutes. After seeing a movie picture on "the cinetic theory of heat", they met again to confront previous ideas with scientific knowledge. Notions of heat, temperature, thermal equilibrium came up and were clarified. The second session was longer, lasting for 90 minutes.

Transcriptions of videotapes were timed: every interval of 5 seconds was marked and considered a "verbal unit", following Carvalho's experience (1987). Then each unit was classified in one or more categories.

We created 17 categories, inspired in Posner's pedagogical suggestions: 9 describe teacher's speeches, 7 describe students' participations and 1 registers moments of silence or confusion.

System of categories

The teacher: *interacts with* **the student:**

. Asks for alternative models:

categ 1 - through opened questions.

categ 2 - through yes/no questions.

.Organizes the debate and encourages participation:

categ 3 - uses, clarifies, relates students ideas; supports students' statements; makes hooks for extension.

.Tries to provoke conceptual change

categ 4 - points out deficiencies or contradictions among students' opinions; confronts them with facts/scientific notions; corrects wrong statements.

.Criticizes student's behavior

categ 5 - reprehends; compels students to participate.

. Answers:

categ 10 - gives his opinion, explains it.

categ 11 - agrees with others, repeats opinions.

categ 12 - desagrees

.Asks for explanations

categ 13 - raises questions; tells his difficulties; cannot conclude his thinking.

.Introduces conceptual change

categ 14 - changes his alternative conceptions; uses/applies scientific knowledge.

.Criticizes the activity

categ 15 - criticizes the course; refuses to participate; talks about other subjects.

.Presents_scientific_knowledge

categ 6 - using analogies, examples, videotapes, demonstrations, experiments.

categ 7 - offers/discusses historical, technological, epistemological and social perspectives.

categ 8 - explains theories and laws, uses formulae, does exercises.

.Intervenes_in_other_ways

categ 9 - stablishes objectives; gives directions; and all statements not suited in other categories.

.Intervenes_in_other_ways

categ 16 - all students' assertions not suited in other categories

categ 17 - silence or confusion.

Some examples and explanations may be usefull.

Category 1 - "Rhetorical questions" along teacher's exposition were classified in categories 6, 7 or 8.

Category 3 - Here is the moment to praise alternative models, not to criticize them (category 4). The purpose is to clarify and articulate students' ideas, as a necessary introduction to debate. This category includes expressions of reinforcement and acceptance like: "good"; "I like what you said"; "listen to what he said, I think he solved the question "; "I think you are not convinced". When the teacher brings more of his own ideas, we shift to categories 6, 7 or 8.

Category 6 - Here the teacher is particularly concerned with the intelligibility of the scientific theory.

Category 7 - Deals with the fruitfullness of scientific knowledge.

Category 8 - Refers to the theoretical and mathematical formulations of the topic in study.

Category 9 - Here the teacher explains the purpose of the activity and how it should be done. It deals also with the important function of teaching how to study, how to interpret graphs, how to manipulate instruments in the lab...

Category 15 - Students complain: "I am completely lost"; "after this discussion, would you explain what heat and temperature are?".

To carry out the second study we selected samples from the beginning, the middle and the end of JOHN'S COURSE. In the first one students debated the question: "what's the difference between heat and temperature?" In the second, they read and commented a text written by Fahrenheit. The author expressed the same doubts arisen by the class. He explained how he deviced instruments and experiments to test his hypothesis The third meeting took place in the middle of the course: it corresponds to the second session described in the previous study. The fourth meeting starded with the question: under the same conditions which one boils first, water or oil?" During the fifth meeting students invented a thermometric scale and learned how to convert it to a centigrade scale. And in the sixth sample they interpreted heating graphs to calculate heat capacity. Each session was 45 minutes.

Here again the transcriptions of videotapes were marked evey 5 seconds. These "verbal units" were classified in one or more categories..

Some of the transcriptions were classified by two judges. Agreement between them varied from 80.5 to 97.9%.

RESULTS

First Study - Different Styles in Guiding Discussions

Table 1 summarizes the different ways teachers and pupils participate in the debates (in percentual figures).

In all the debates teachers participate more than the students (Mary's speeches were 58 and 59% of total classrooms discourse. John also monopolised the dialogue (55.5 and 67.5), mainly in the second meeting .

Both teachers spent a long time explaining or justifying the activity (category 9 in Table I) and encouraging participation (category 3). This suggests that students felt uncomfortable, uncertain or confused about what to say and unable to succeed.

To stimulate participation, MARY asked questions (categories 1 and 2). This strategy was largely used in the first session (17% of her speech): "What do you think?"; "How does the flame heat the kettle?". On both meetings she tried to praise their conceptions (category 3 = 14 and 16%). But she seldom organized students' ideas, nor helpd to clarify them. Instead of focusing one issue at a time, she raised various questions which significance was not clear. Cognitive conflicts were not stressed (category 4 = 0 and 0,2%).

During the first session MARY'S STUDENTS gave their explanations about "what is going on as we heated an object". But in the second meeting their participation was poor (14% of classroom discourse). Looking at category l7 we see that noise and confusion were very high (27% of the time). The teacher criticized their behavior (category 5 = 5 and 10%). They claimed that discussion was going on and on unproductively and aimlessly.

TABLE 1

Percentage of teachers' and students' participations in classroom debate according to 17 categories.

		MARY			JOHN	
session / category	**1st**	**2nd**		**1st**	**2nd**
1	16	7		2	3
2	1	3		5	6
3	14	16		25	12
4		0.2		5	1
5	5	10		0.5	0.5
6		2		3	26
7					0.5
8					4.5
9	22	21		15	14
Sub Total	***58***	***59***		***55.5***	***67.5***

	MARY'S STUDENTS			JOHN'S STUDENTS	
10	25	5.5		13	6.5
11	2			4	3
12				0.5	2
13	5	2		6	5

14		0.2	10	2
15		2	1	1
16		2	4	3
Sub Total	***34***	***14***	***38.5***	***24.5***
17	8	27	6	10

The reproduction of a tale from this last session will illustrate the degree of lack of communication, dissatisfaction and tension:

T: Look, there is something I want you to discuss, something that I think is important. It is Carla's and Roberta's idea. Who are they? ...Look, they said that - pay attention -....when the water is frozen the molecules contract. Some of you said that heat inflates the molecules and to prove it you said that bottles full of water blow up in the feezer. But if the molecules contract, how do they blow up?
S: I know... under a certain temperature...
T: Wait a moment.
S: May I speak?
T: Say.
S: Under a certain temperature the water turns to ice. The density stays over the ice. As the ice doesn't go up the animals don't die. That's the way I think. I know that is because of that.
T: But what I am asking is independent of that...
S: But we can't take something independently.
T: No. Wait a moment. You said: when it is hotter the molecules get bigger and when it is colder they shrink. Pay attention. Please pay attention. Look, I see you don't want to discuss.
S: We are discussing for four sessions, but we don't go on.There's nothing more to say. We need information to go further.

MARY's introduction was confused. She started putting them in front of a contradiction, instead of clarifying ideas and building up explanations first. She did not prepare students to face cognitive conflict. On the other

hand, they did not grasp the contradictorial nature of the statement. They just picked up a detail as a pretext to make up a story about animals living in very cold areas.

JOHN preferred to organize the discussion (category 3). Almost half of his speech had the intent to accept, repeat, clarify, synthetize students' points of view, trying to improve understanding and relevance. He used to raise one issue at a time. Participants showed signs of cooperative and constructive thinking (category 14 = 10%), as we see by the following transcription:

T: What's the difference between heat and temperature?
S: Temperature would be a measure and heat would be a fase.
T: Heat would be a high temperature and cold would be a low temperature. Now, look: water boils at 100º C. Many of you said that the temperature stays constant while the water is boiling. The question is: if the fire is giving more and more heat, how come that the temperature is the same?
...
S: The excess of heat goes out with the steam and the temperature stays on 100º C.
T: The excess goes out with the steam.
S: It is like that.
T: You think that it can be that way.
S: I do.
T: More and more heat is being sent to the boiling water and where does it go if the temperature is the same?
...
S: Teacher, just to complete that explanation. The water turns into steam after 100º C. So, the liquid water that is in the kettle can't be over 100º C, otherwise it would turn into steam. That's why the temperature of the water in the kettle stays constant.
T: Do you mean that while there is water in the kettle the temperature couldn't be 150º C for instance?
S: No, because at this temperature the water would be steam, and not anymore in the liquid state.
S: Does the temperature stays at 100º C?
T: You're not convinced. Did you ever see that? Did anyone see that?

Many voices: no.
T: As many of you have doubts, we will go to the lab next time to verify this.

The meeting was productive. Some students made up their minds about the topic. Most part of them got a better understanding of the problem but were not convinced. They needed arguments stronger than words. They needed facts. In Posner's words, the conceptions discussed have been intelligible but not plausible.

In the second meeting JOHN continued to structure classroom discourse and started nourishing it with information presented in informal way (26% of his speech). Verbal interaction could be characterized more as a dialogued lecture than as a discussion. Concepts were reviewed and summarized. Teacher's participation raised up to 67.5% of total classroom talking and students'dropped to 24.5%. Here cognitive conflicts were not stressed neither explored (category 4 = 1%); conceptual changes seldom occurred (category l4 = 2%).

Second Study - Teacher's and Students' participation in classroom discourse along the semester

As the course went on teacher's participation in the dialogue increased: in the first meeting he spoke aproximately 50% of the time; in the sixth session his speech represented 76.5% of the whole conversation. Students'participation dropped from 38.5 to 13%.

As the course proceeded more attention was given to the presentation of scientific knowledge (categories 6, 7 and 8 in Table 2). In the first meeting only 3% of the statements were informative. During the last three sessions aproximately 40% of teacher's speech had informative nature. He showed great concern in making theory intelligible (category 6). He spent a long time giving examples, developing appropriated and motivating analogies, doing demonstrations, going to the lab. The theoretical and mathematical approaches were introduced slowly (category 8).

TABLE 2

Percentage of JOHN'S and STUDENTS' participation in classroom discourse along the semester

Semester		beginning		middle		end	
session	category	1st	2nd	3rd	4th	5th	6th
T	1	2	14	3	6.5	4	4.5
E	2	5	2	6	4	3	6
A	3	25	19	12	14.5	11	8
C	4	5		1		0.5	
H	5	0.5		0.5			
E	6	3		26	19	7	41
R	7		20	0.5	6		
	8			4.5	20	29.5	2.5
	9	15	6	14	8	16	14.5
Sub Total		***55.5***	***61***	***67.5***	***60***	***71***	***76.5***
	10	13	17	6.5	10	4	3
	11	4	1	3	4		2.5
	12	0.5		2	8		1
	13	6	3	5	6.5	7.5	0.5

14	10	2	2	1	5	5.5
15	1		1			
16	4	5	3	1	2.5	0.5
Sub Total	***38.5***	***28***	***24.5***	***31***	***19***	***13***
17	6	10	11	9	10	10.5

To test understanging, to promote participation and to raise divergent ideas, JOHN used to ask yes/no questions like: "in a piece of ice are the molecules agitated or motionless?"; "under the same conditions, which one boils first, water or oil?" But, except in the first session, he did not explore the questions in depth, neither used them as a strategy to introduce cognitive conflicts - (the percentage of statements in category 4 varied from 0 to 1%). These yes/no questions seemed to help "awaken" tired students.

Attention with the organization of classroom interaction decreased (in category 3, figures dropped from 25% to 8% in the last sample). But along the course he continued guiding students how to study and interpret graphs, how to work in the lab, how to solve problems (category 9).

Samples registered very low frequency of criticism (categories 5 and 15). This allowed a spontaneous climate of study.

JOHN'S STUDENTS took a small part in classroom interaction, and it got smaller as the course advanced.

The more frequent way of participating was giving answers to teacher's questions (categories 10,11 and 12). Statements of desagreement were rare (category 12), despite the importance they play in the constructivist approach and teacher's strategy to stimulate them: in the fourth session he asked students to raise their hands in agreement with the question: - "who thinks oil boils first?" - and then: "who thinks water boils first?"

Conceptual changes were registered in all the meetings (category l4). The moments when they had higher frequency ocurred in the first meeting and in the last two sessions. In the first case conceptual change were modelled and constructed during verbal interaction, as we have seen in the previous study. In the last two samples, changes appeared as results of instruction and not as a process of overt interaction.

DISCUSSIONS AND COMMENTS

The classification of verbal utterances poses theoretical and practical problems. It is difficult to discriminate speaker's intentions and to find clearcut boundaries among categories (Griffin, Cole & Newman 1982, Schegloff 1984, Cazden 1986 and Hewson & Hewson 1987).

Despite these limitations, categorising classroom discourse according to Posner's theory furnished a structured overview and relevant insights, revealed unsuspected aspects and difficulties about the social construction of knowledge in instructional context.

The lack of provocative questions surprised us. One hypothesis for this fact is related to the distance between intended teaching ideas and teaching practices (Carvalho 1989). It may be that alternative teaching concepts are as robust as students misconceptions. Conceptual changes on teaching could be improved in teacher education programs. That is something we are now investigating.

On the other hand, students not always grasped the conflicting nature of a given issue. Trying to rescue it teachers restated the question. Confronted with a provocative yes\no question, students promptly participated. They almost never desagreed. But they did not go further, searching, speculating or creating new explanations: did they feel unable to overcome problems? Did they resist to think?... Very often they received teachers answers: why to give them prompt answers, instead of helping them find theirs? How to provide this kind of help? Constable and Long (1991) have already registered how teachers felt unable to monitor social construction in the classroom. This is another important avenue of investigation

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