CONSISTENCY OF AN OPTICS LESSON INCLUDING ICT AT GRADE 8

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ABSTRACT
This paper presents an analysis on the implementation of an ICT-based activity in a physics lesson about optics at grade 8 (lower secondary school). This activity aims at introducing the additive synthesis of colors with the help of a simulator. The analysed activity has been elaborated within a research-development group associating secondary school teachers and a science education researcher. The teachers followed in this study are informed both of the conceptual objectives and of the underlying hypotheses related to modelling process. The simulation can be used as a reference experience all along the lesson. It allows students to compare their previous ideas to the simulation results and to the real experiment results. This comparison can be used to explicit the modelling process underlying the presented simulation.

KEYWORDS
Modelling process, communicative approach, multimodality, simulation, physics.

INTRODUCTION

The importance and the use of ICT devices are growing in the practice of teaching science. The functions and didactical objectives of teaching with these tools are diversifying. For the same class, same material and same chapter, we find a variety of software. The teacher then has to choose among this wide range of software. However, most of the time, these programs are not accompanied by information resources that explain their use and their underlying hypotheses of learning. This has been reported as a “great defect” by de Vries (2001).
The mastery of these technological tools requires much time and personal investment both in terms of their management and their integration into instructional settings. Therefore, it is possible for some teachers to believe that ICT determines knowledge. On the contrary we consider that the ICT activity has no meaning in itself; it acquires its role in linking the different parts of the session. The teacher has a major role in building the consistency between these parts. This consistency is at least partially built on the links between the models and the proposed experiments. These links are constructed and made explicit through verbal interactions among students and between the students and the teacher.

THEORETICAL FRAMEWORK

In order to analyse the consistency of the lesson and the learning opportunities, we chose to build a theoretical framework articulating an epistemological point of view concerning modelling and another point of view related to the interactions in the classroom.

Modelling as a basis to teach and learn physics

Some researchers consider that modelling has an origin in an epistemological judgment on the deep nature of physics and chemistry. They present the modelling processes like a core of physics and chemistry. The importance of modelling in learning physics is often reflected by the fact that the models are products of scientific activity. They appear as an ideal tool for transmission of information between teacher and students to explain, interpret and predict phenomena.

For Martinand (1992), the modelling process requires consideration of three levels: the theories, the models and the empirical referent.
For Tiberghien (1994), the process of modelling in the teaching of physics requires the articulation of three levels: the theories, the models and the material world.
In this article, following Tiberghien (1994), by "world of objects and events" we mean any element of knowledge which refers to the material world. By "world of theories and models" we mean a qualitative or quantitative tool can related to the understanding of what is happening in the world of objects and events.
During instruction it is necessary, that the teacher clarifies that it is difficult to consider all aspects of the world of objects and events in the creation of a model. Therefore, each model is defined by its domain of validity.
Most of the time, the students' problem lies in the fact that the theory they use draws on common sense and everyday life, and has little in common with the theories of physics they are expected to use and to learn. Therefore, establishing such distinctions and relations between the material world and the world of theories and models requires a lot of work from the teacher. This distinction helps students to confront their own point of view with the theories and models of physics.
Tools such as a simulation can allow students to model, that is to become aware of the difference between the world of objects and events and the world of theories and models.

The communicative approach

Different studies in science education are carried out to study how meaning is constituted in a class through the language and other communication methods. The aim is to know the ways in which understandings are developed in the social context of the science classroom.
The framework developed by Mortimer & Scott (2003) provides a perspective on how the teacher works with students to develop ideas in the classroom. The framework is based on five linked aspects which focus on the role of a teacher: "teaching purposes", "content", "communicative approach", "teacher interventions" and "patterns of interactions". In this article we focus our attention on the communicative approach.
We first define the concept of point of view to go beyond common sense. Following Rabatel (2005, p.96) we call *"point of view"* an utterance which carries a given meaning; by the way it makes reference to elements of the world, the point of view gives information both on its semantic content and on its emitter.
According to Mortimer & Scott (ibid.), the communicative approach in the teaching discourse may be dialogic or authoritative. It is qualified as dialogic when the teacher takes into account different points of view, generally stated by students. The communicative approach is qualified as authoritative when the teacher takes into account only one point of view that is usually based on the scientific knowledge s/he wants to teach. This dialogic/authoritative dimension is independent on whether it is uttered individually or between people. This point leads the authors to present a second dimension: interactive or non-interactive. The approach is qualified as interactive when it involves the participation of more than one person in the discourse and as non-interactive if only one person participates.
The type of the communicative approach between teacher-student may not be unique within a class: the teacher changes the communicative approach whenever s/he thinks it necessary. Scott et al. (2006) consider that changes in the communicative approach promote learning: "the transition between dialogic and authoritative interactions [is] fundamental to supporting meaningful learning of disciplinary knowledge as different teaching purposes are addressed" (Scott et al., ibid.).
In this presentation, we will study the classroom discourse on the basis of the communicative approach theory and of the modelling processes in play. We will particularly concentrate our analysis on the emergence and development of point of views in relation to the modelling level they refer to.

RESEARCH QUESTION

Taking into account our theoretical framework, our research question can be stated as follows: for a given activity, how can the choice of an ICT tool coupled to a physical organisation of the session influence the learning opportunities and the nature of the discourse?

BRIEF DESCRIPTION OF THE STUDIED LESSON

General context of this study

This study has been carried out in the context of a research-development group that designs teaching sequences for physics (Bécu-Robinault, 2007; Buty et al., 2004). All the teaching sequences have been co-elaborated by researchers and practicing teachers, implemented in classrooms in order to be assessed from teaching and learning perspectives. This presentation concerns the optics sequence at grade 8, lasting three months in the French school system. We focus here on the fifth activity out of seven. During the elaboration of the teaching sequences, a number of hypotheses have been considered, related to misconceptions concerning optics, modelling, and communicative approach. Thus, the teachers implementing the sequence were aware of epistemological and communicative points of view presented in our theoretical framework. This fifth activity is devoted to the reconstruction of white light (daylight) from three coloured lights (green, blue and red). This reconstruction will be called in following sections "additive synthesis".

Teaching context

The teaching sequence is built as a consistent whole from a conceptual perspective: each activity takes into account what has previously been done. We here precise the previous teaching content students have been confronted with:

- In a first step, students experimented everyday life situations in order to see that the sunlight can be broken down into several coloured lights;
- The daylight spectrum was then presented and studied ;
- A number of objects were studied to understand the role of coloured lights in the vision of the colours of the objects. At that time, coloured filters were also studied as coloured objects and objects that enable to change the colour of the daylight.
- Just before this activity, a brief introduction to energetic effects of lights on coloured objects was done.

The studied activity

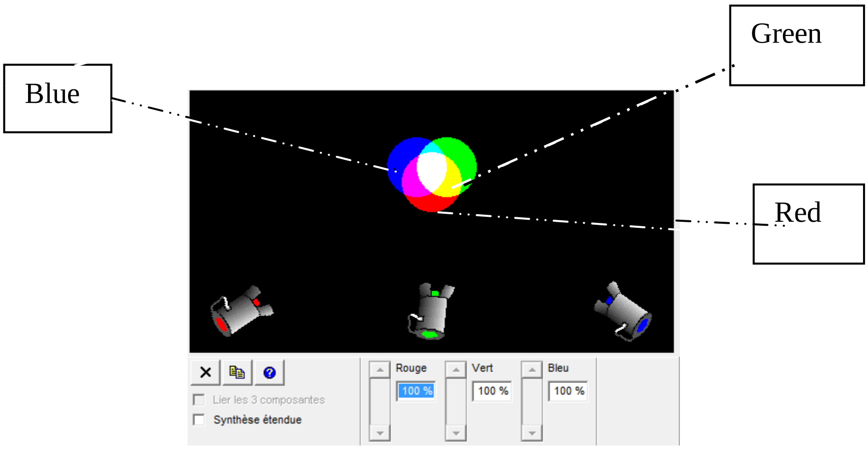
During the fifth activity students are asked to use an ICT device presenting a simulation of the additive synthesis. Beyond the physics content, "additive synthesis", the use of ICT is expected to reach a more general teaching objective, which is to visualise the differences between a simulation and a real experiment. In what follows, we reproduce the main three steps of this activity, corresponding to the written instructions given to students; and we describe the device the students interact with.

1- Students fill table 1 by predicting the coloured light obtained when superimposing two or three of the blue, red or green lights.

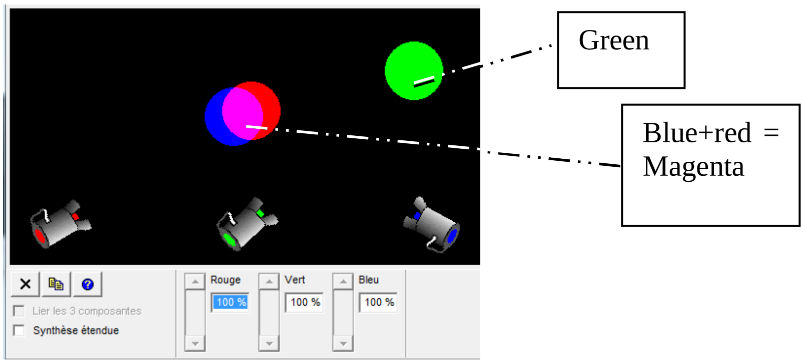
Table 1. Predictions concerning the coloured lights obtained

Colours of spots put on			Coloured light obtained
Red	Green	Blue	
X	X		
X		X	
	X	X	
X	X	X	

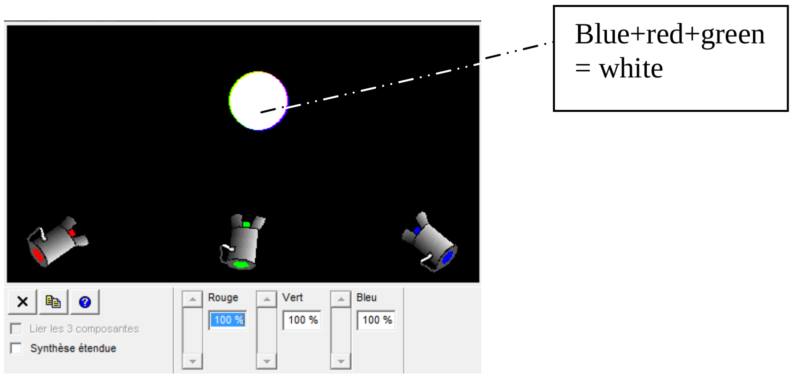
2- Students compare their predictions with the results shown on the screen of the simulator Visiolab[1] (figure 1) and fill a second table (table 2). When opening this ICT tool, we visualize on the screen three coloured spots on a black wallpaper. Initially, the three spots are alredy superimposed (figure 1). Three lamps appear at the bottom of the screen and three cursors allow to modify the light intensity. The students can change some parameters such as the intensity of lights, or the diameter of the spots. To move the spots, students must pull them with their mouse. It is not possible to move the lamps directly; their movement is a consequence of moving the spots



Screen observed when starting Visiolab



Screen observed when superimposing red and blue



Screen observed when superimposing red, blue and green

[1] http://www.discip.ac-caen.fr/phch/college/quatrieme/tp_physique/synthese_couleur/synthese_couleur.htm

Figure 1: Screen captures of Visiolab with different superimpositions.

Table 2: table to fill with results obtained with Visiolab.

Colours of spots put on			Coloured light obtained by superposition	
Red	Green	Blue	Colour this box	Name of the colour obtained
X	X			
X		X		
	X	X		
X	X	X		

3- Proposition of a real experiment and comparison of the results obtained in both situations (ICT and real experiment). The experiment should be carried out with the material usually available in the classroom: an optic light (figure 2), enabling the production of three light sources with a single lamp and two pivotal mirrors.

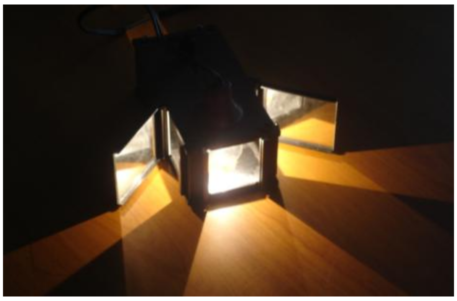


Figure 2: The optic light used in the classrooms

METHODOLOGY

In order to analyse how the choices of teachers modify the learning opportunities, we chose to follow a male teacher~~, who was~~ participating in the research-development group. He accepted to implement the whole teaching sequence without modifying the written instructions. However, he was completely free to stage the activities so that they fit with his usual practices. He has ten years of teaching experience and is at ease with classroom debates. In his school, the teaching materials are limited even if they have a classroom with computers at their disposal. The population of the school is mixed. A group of students and the teacher were videotaped. One camera recorded the teacher interacting with the whole class. This camera was placed at the back of the room. The second camera focused on a group of students.

A transcript of verbalizations of the group of students and of the teacher was made and written; the documents distributed by the teacher were collected.

DESCRIPTION OF THE DIFFERENT PHASES IN THE LESSON

In the class, each group of students is given written instructions and a computer. The videotaped group is composed of two boys and one girl (Nicolas, Corentin and Julie). Due to limitations in the available material, there are no optic lights at the disposal of individual students. The teacher planned to carry out the experiment himself in front of the classroom.

First phase: group work

The teacher asks students to discuss in groups to fill the first table. When they finish, they move and sit in front of the computers to complete table 2. Students return to their places (away from the computer) when they finish the proposed task (filling in table 2). Therefore, the computer is not a reference material presented throughout the session: it may be difficult to compare the results obtained on the screen of the simulator and the real experiment if the elements to be compared are not simultaneously presented.
Due to constraints related to the available material, the teacher asks students to give him a list of the materials usually available in the class of physics to obtain the same result than observed on the screen of the computer (that is, to produce white light from three coloured lights) and to draw a symbolic representation.
A few minutes later, when the teacher goes to students individually, he discusses with the videotaped group their proposal. During this discussion, two points of view emerge:
The first point of view, given by Corentin and Nicolas, is to "make a package with three filters" and then send the colour of white light from a single source. When the teacher listen their proposal, he asks the question “do the three of you agree?”. Julie expresses her disagreement with the proposal made by the two boys. After the proposition of Julie, a second point of view emerges: the students propose to use three sources of light, each associated with a filter.

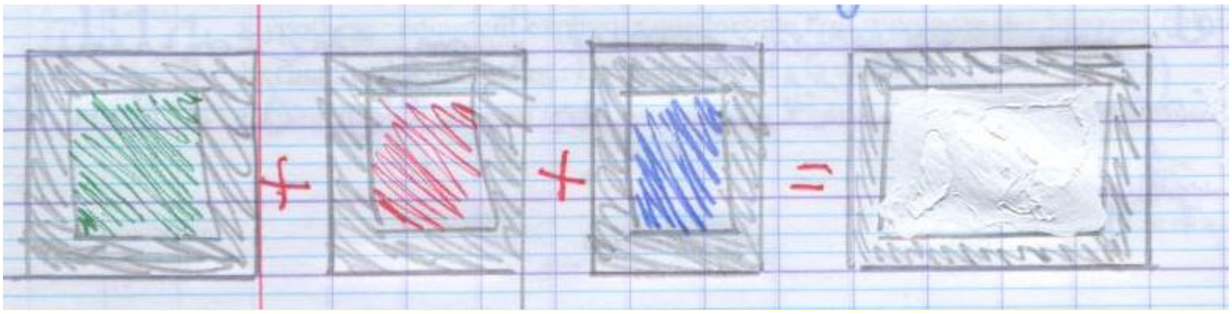


Figure 3: Drawing made by the students: the first filter is green, the second is red and the third is blue. The last one has been painted in white.

Second phase: collective debate
A few minutes later, the teacher initiates a collective debate to answer this question. This debate is grounded on the students’ answers the teacher picked up during the previous phase. Different groups of students are asked to propose their experiment. It appears from the transcript that three points of view are developed. The teacher picks up only two of those:

- Antoine proposed to send white light from a single source on three stacked filters (three coloured filters = white filter equivalent). This point of view is similar to the point of view of Nicolas and Corentin during the group discussion.

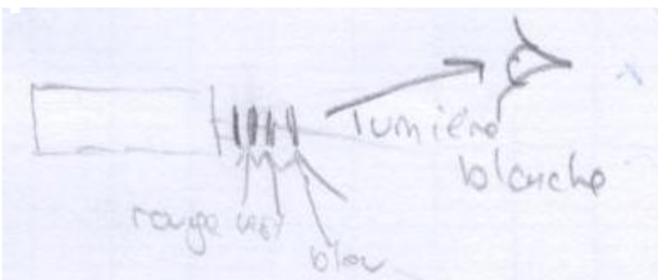


Figure 4: Drawing of Antoine.

- Cheyenne (from another group) proposed to send three lights from three light sources on three different filters. This proposal looks like the second proposal given by the videotaped group.

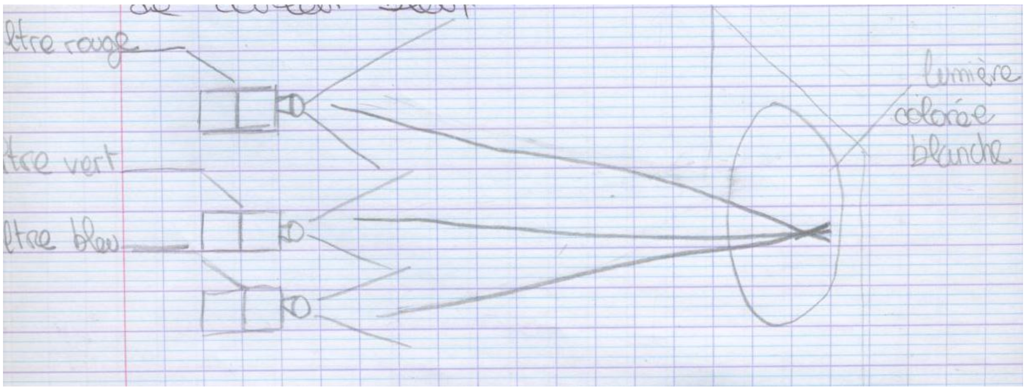
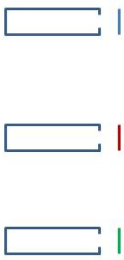


Figure 5: Drawing of Cheyenne

- The third point of view is close to the sequential reasoning in electricity. Another student (Luc) suggests that the three filters will transform the colour of the light one after the other. He does not consider the three filters as a whole but successively transforming the colours in order to produce, at last, white light. This point of view is not taken into account by the teacher. This point of views is related to a misconception concerning the role of filters: a coloured filter is a tool to transform any light in a coloured light corresponding to the filter's colour.

Third phase: experiment in front of the classroom
The teacher is testing the experiment (proposed by students) himself on his desk in order to choose the most suitable. He uses a lantern (Figure 2) and three coloured filters. To end the activity, the teacher draws on the whiteboard three lanterns and coloured filters: red, green and blue.



: lanterns; : filters

Figure 6: Schematic representation reproducing the drawing of the teacher on the whiteboard. The first filter is blue, the second is red and the third is green.

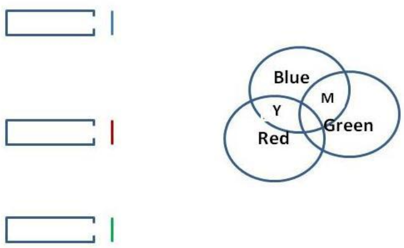
Detailed analysis of the discourse
Depending on the issues that we proposed to answer we present excerpts from the classroom discourse. Some extracts are analysed from the perspective of the modelling processes and further analysed in terms of communicative approach~~-~~.

Analysis - modelling
Earlier in the session the teacher's talk refers to red and green coloured lights~~: red coloured light, green coloured light, ..~~. The teacher does not speak in shortcut terms ("red, green~~, ...~~"). These words are always followed by the word "light". In addition, the software strengthens this lexicon, which provides

a learning opportunity. This attention to the lexicon is due to the fact that the teacher is aware of the difference of the colours terms between physics and visual arts. The teacher does not make explicit this difference to students during the debriefing at the end of the session. The discussion is presented in the following:

P :… a~~a~~nd when superposed blue coloured light red coloured light and green coloured light three coloured lights, that gives the whole
E: white
P: it gives white light coloured/ is it the same when painting ↑
E2: yes
E: yes
P: when we mix red paint to blue paint and green paint we obtain the white ↑
E (many): no
E: black
E: brown
P: we obtain a kind of brown
E3: khaki
P: yes ok you already have mixed a lot of paint you get white ↑
E2: no
E: well no
P: so is it the same paint and light ↑
E2: well no
P: paint is a colour it is a matter colour is a matter it's material colour you agree ↑ light is it a matter is that we can touch the light
E: no
E2: no
P: we can not touch it's not the same right we agree

- During the debriefing, the teacher also draws on the whiteboard a representation of the three lanterns and three colour filters. This is followed by a diagram representing circles on the other side of the whiteboard. The drawing made by the teacher on the whiteboard is as follows:



: lanterns;
: filters;
: coloured light

Figure 7: Drawing of teacher on the whiteboard. The first filter is blue, the second is red and the third is green.

We can notice that the teacher has reproduced almost exactly what is presented on the screen of the simulator Visiolab: three coloured spot. Therefore, we notice that Visiolab has provided a symbolic representation of the light. This learning opportunity for the representation of the light spot was not conform to the physics model. In physics, light is represented by rays or by beams.

The teacher did not model the light emitted by the lantern by beams or rays. The representation of phenomena is identical to the simulation: coloured spots and not beams of coloured lights. These coloured spots tend to legitimise the mobilisation of the visual arts model (subtractive synthesis). Moreover one of the written instructions distributed ~~activity labsheet~~ askss the students to name the coloured lights (additive synthesis) and to colour each corresponding square with a pencil (subtractive synthesis). This instruction legitimises both models the students are liable to mobilise.
On the contrary, in the drawing of Cheyenne (figure 5), we observe the modelling done for the beams of light. She drew straight lines and beams to explain its proposals. Moreover, it clarified a point of intersection of rays of the 3 coloured lights to give white light. The white light obtained is represented in their drawing a circle (like Visiolab). We can say that the modelling Cheyenne suggests makes explicit the link between the spots and the light obtained more. It promotes the difference between the two syntheses: additive and subtractive.

Analysis - communicative approach

Due to material constraints, the teacher asks students to propose a method and a drawing to obtain white light with materials available in the classroom. In the collective discussion, we notice the emergence of three points of view in the classroom. The teacher gives the first two points of view the same attention (point of view of Antoine and of Cheyenne) and therefore the communicative approach in this episode is dialogic. The teacher stops to be dialogic when he does not understand the manifestation of the third point of view by a student. He waits 6-7s before announcing he will test the proposal of Cheyenne and Antoine (majority proposal in the class).
Antoine's point of view is based on the visual arts model: he suggests overlapping three filters and then sending the light from a projector (Figure 4). This is a procedure similar to mixing paint.
We hypothesize that the observed spots on the screen of simulator represent the filters for Antoine because he proposes to superpose the three filters as he would superpose the three spots.
Furthermore, Nicolas and Corentin used extensively a lexicon from the visual arts (colour, putting three filters, etc.) without using the lexicon used by Visiolab (light spot, three projectors, and light source).
On the contrary, Cheyenne used the physics lexicon. This lexicon is an opportunity of learning provided by the ICT. The same vocabulary was used by Julie to indicate that the proposal of the boys was not relevant (only one light source and three filters). Julie spoke of "spots", "three different overhead" and "coloured lights that overlap" which is the physics model.
Indeed, in her drawing, Cheyenne makes explicit that each filter will be placed on a source (even if it does not quite put filters in relation to sources in her drawing, Figure 5).

CONCLUSION

In this article, we studied a case on a specific activity at grade 8 in French school. The activity is built on an ICT simulator followed by real experiments. We have studied how an ICT coupled with real experiment can influence the development of knowledge and communicative approaches.
The choice of an ICT tool coupled to a physical organization of the session offers two learning opportunities. The first learning opportunity emerges by a special lexicon referring to the physics models (spotlight, light…); the second learning opportunity is the system of symbolic representations of the light that is not based on physics references. Within the physics model, the light should not be represented by coloured spots or circles but by rays or beams. The students (Julie, Cheyenne) and the teacher have used the physics lexicon and the symbolic representation of light (circular spots). These symbolic representations are in the mind of students when working with real experience.
Thus, a characteristic of the kind of mental work that the used ICT device promotes is multimodality. Although multimodality can be seen as "the normal state of human communication" (Kress, 2010), very often in school settings, its potentialities are underestimated and underused. This apparent paradox is the more surprising when using computer-based simulations, which offer a richer panel of semiotic affordances than traditional school tools. The reason can well be rooted, as Kress points out (2010, pages 174-183), in the necessity of assessment, and that is an issue long ago raised and studied for computer-based teaching and learning. To speak in Kress' terms (id., page 183), there is an opposition between the metrics of learning and the signs of learning: the kind of work, of learning, that Julie,

Cheyenne or even Antoine have performed, their ability to articulate words and images coming from the computer, will probably never be assessed and taken into account in their school performance.
In order to provide more learning opportunities and to solve the constraint equipment, the teacher chooses to carry out the experiment himself and to organise a debate. The communicative approach serves to solve the problems arising from resource constraints. In the same time, it allows to eliminate the ambiguities coming from the interpretation of the various systems of signs the students are confronted to.

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