Coherence of an ICT-using Teaching Sequence: a Case Study in Optics at Lower Secondary School

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COHERENCE OF AN ICT-USING TEACHING SEQUENCE: A CASE STUDY IN OPTICS AT LOWER SECONDARY SCHOOL

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Abstract: This communication reports a case study based on a discourse analysis in an ordinary classroom, at grade 8 in a lower-secondary school in France, during a teaching sequence in elementary Optics. It particularly focuses on a part of the last session, where the eye is presented as an optical system using a lens, the focal length of which is variable. For this part, the teacher is using a computer-based simulation. The teacher's discourse is analysed from a threefold point of view: the modelling processes; the conversions between several semiotic registers; the coherence between this session and previous activities in the teaching sequence. From all these points of views, the use of an ICT tool offers new learning opportunities to students, or strengthens learning opportunities already offered.

Keywords: ICT, Coherence, semiotic representations, modelling processes, affordance.

1. INTRODUCTION

ICT-based tools have reached a high level of use in science teaching in developed countries; they have multiple uses (among different typologies, see for example Pinto and col., 2010). This use can be seen and studied more specifically, for instance when an ICT-based device is chosen by the teacher to fulfil a specified task, at a given moment of a teaching sequence. As far as students' learning is taken into consideration, the long-scale effects that is, the coherence of the ICT use regarding the other parts of the teaching sequence, must be analysed as well: what is the role of an ICT device in a teaching sequence? Is it used to introduce new notions or to reinforce concepts that have already been studied?

The theoretical tools that we shall use in this case study take into account the multimodal dimension in science teaching and divide among three elements: the modelling processes, the semiotic registers and the affordances or learning opportunities.

2. THEORETICAL FRAMEWORK

2.1. Modelling processes

Models and modelling are an essential dimension in science teaching. Tiberghien (1994) distinguishes between two worlds in teaching/learning physics. She defines:
- the world of objects / events as knowledge elements that refer to the observable and material world,
- the world of models or theories, as qualitative or quantitative notions and procedures that correspond to the generalizable aspects of the studied situation.

From this epistemological point of view, physics teaching can be considered fundamentally as a matter of modelling processes, of establishing meaningful links between "the world of objects and events" and "the world of theories and models".
Very often, ICT-based tools represent models of empirical realities, and one of the tasks of the teacher is to make this status clear for the students. For instance, in our case, the software used in physics (Cabri-Géomètre[1]) obeys the rules of physics and its representations belong to the world of theories / models.

2.2. Semiotic registers (semiotic representations)

Science classroom discourse is a particular one. It is multimodal in principle (Lemke, 1998) and uses several semiotic registers. Duval (1995) defines the semiotic registers in the following way: "they are the productions made by the use of signs (utterances in natural language, algebraic formulas, graphs, geometrical figures…)".

When using ICT in science classroom, many modes of representation, many "semiotic register" are used in the classroom discourse; the dynamic graphical representations, which are the core of most ICT-based tools, must be articulated with natural language (words and gestures as well), or static graphical representations (drawings or schemas on the blackboard, for example), or mathematical symbolism.

Duval defines some semiotics registers in mathematics education. We take in the following semiotic registers very often used in teaching physics:

- The register of natural language: it is the primary tool used before and / or during the acquisition of scientific vocabulary. This register is flexible that is, used in the world of objects / events, the world of theories / models and to make a link between the two worlds.

- The register that contains drawings, diagrams, and graphs:

a- a drawing is an "exact representation of the shape of an object" (Davy & Doulin, 1991);

b- a schema is a representation of a referent. It can be non-figurative and figurative. A figurative schema refers to something sensible, visual and perceived while a non-figurative schema designates a mental referent. (Estivales, 2003, page 56).

2.3. Affordance versus Learning opportunity

The psychologist James Gibson proposed the term "affordance", in his ecological theory of perception (Gibson, 1979). He noted that the affordance depends on interactions between the animal and its environment: "*affordances as what the environment offers the organism"*.

In the field of ICT-based science education, Webb (2005) expresses a definition for the notion of affordance inherited from Gibson: "*In an ICT-supported learning environment affordances are provided by interactions between the hardware, software, other resources, teachers and other students*" (Webb 2005, p.707).

We consider as meaningful to introduce a distinction between two phases of teacher's activity when implementing an ICT-based activity in the class, regarding the coherence of the teaching sequence and the effects on learning. This distinction is a consequence of our socio-cultural point of view on science learning, which gives a key role to social interactions in the construction of knowledge.

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[1] www.cabri.com

When a teacher plans to use an ICT-based tool in a teaching session, he or she first chooses the software (or special functionalities of the software), depending on the school equipment, on the starting point of the students, on the teaching aims, etc. The teacher also foresees the way he or she will play the scene. We keep the term "affordances" for this set of characteristics that are planned before the session begins.

During the activity itself in the class, the interactions can widely modify what has been planned. When we analyse the classroom discourse, we find evidences of unpredicted suggestions by students, or unforeseen procedures (right or wrong) they use, which deviates the knowledge flow in the classroom discourse and activity, and consequently which can activate or inhibit previously organized affordances. We call *learning opportunities* the affordances that have been effectively offered to students during the classroom interactions; students can catch or not these opportunities, this is another question asking for different methodologies.

2.4. Links between the theoretical tools

These four kinds of theoretical tools are relevant with our purpose to analyse the coherence between the moments when the teacher uses ICT-based activities, and other moments of the sequence. These two kinds of activities can be at different modelling levels, on one hand, and use different types of representations on the other hand. Moreover, the term of affordance, as defined by Webb in the cited sentence, is essentially an integrated one, insisting on the various facets that constitute an affordance.

3. RESEARCH QUESTION

Taking into account the previous theoretical elements, the questions in this study are: how does the use by the teacher of an ICT-based tool construct the coherence of a teaching sequence? How does the use by the teacher of an ICT-based tool offer new learning opportunities to students, in the flow of classroom discourse?

4. METHODOLOGY

We have filmed a male physics teacher at the lower secondary school in France, during a complete teaching sequence. This sequence consists in six activities, each session lasting one hour and a half. This sequence[2] is a research-based one, as it has been elaborated in a joint group involving a researcher and several teachers.
We have indexed our video data of the entire sequence in a table (script). We identify the sessions where the teacher used the software Cabri in the sequence: two times. We have chosen to present here the analysis of a single use of Cabri (the second one, May 25).
We particularly looked at the moments when the teacher used the software, and we transcribed these moments. In the discourse of the teacher we searched all the indicators relating to the activities earlier in the sequence.
We present below (table 1) the "script" of the sequence including moments where the teacher used the software.

Date of the	Number of the activity	Learning objective indicated at the beginning of each activity	Content of the activity

[2] See the current version at http://pegase.inrp.fr/theme.php?rubrique=1&id_theme=57

session			
2010_04_06	Activity 1 Activity 2	1. Recognize the different types of lenses. 2. Understand the effects of a converging lens in terms of optics.	1. The students work in pairs to find among four lenses, which of them can serve as a magnifying glass. The strategy consists in looking through the lenses. 2. The teacher introduces the terms *diverging* and *converging* lenses.
2010_05_11	Cabri (addition)		*Modelling a converging/diverging beam of light after passing through a converging/diverging lens.*
	Activity 3	3. Show that the energy is concentrated at the focus of the converging lens for sources situated at the infinite.	3. The students carry out experiments using a thermometer, a converging lens, a screen and a lamp. Students place the lamp as a light source followed by a converging lens. They measure the temperature of the light spot formed on a screen as they move it from the lens.
2010_05_18	Activity 4 Activity 5	4. Show that some specified condition is necessary to obtain an image . 5. Understand the vision mechanism from the point of view of optics.	4. The students send the light of the lamp on a slide with the letter P. The light passes through a fixed converging lens. Students move the screen (backwards and forwards from the lens) to obtain an image. 5. The students establish the correspondence between the terms mentioned in the drawing of the eye (figure 1) and the following words in the text: diaphragm, converging lens and screen.
2010_05-25	**Cabri (addition)**		*Correspondence between the elements of the eye in a schema and a drawing.* *Convergence of the rays passing through a lens when they come from an object at a finite distance or an infinite one.* *Explanation of the accommodation phenomenon.*
	Activity 6	6. The corrective lenses for the eye defects.	6. Correction of eye defects.

Table 1: Script of the sequence titled "lens" (grade 8). The use of Cabri-files that has been analysed took place on May 25 (bold characters).

It was not planned to use Cabri-Géomètre in the sequence. That is why we have not completed the learning objective on the corresponding lines. The teacher was proposed to use Cabri files in this sequence by one of the authors, as they may facilitate the understanding of the modelling processes by the students.

5. ANALYSIS

We present the results of analysis according to each theoretical framework.

5.1. Analysis in terms of modelling processes

5.1.a. Analysis of the files realised under Cabri Geomètre

Cabri was used to model the convergence of light rays after passing through a converging lens. On this file, the teacher has the possibility to choose and modify the location of the object (finite distance, infinite distance) from the lens.

These Cabri files obey to the laws of Optics, and the representation obtained by Cabri refer to the world of theories / models.

Nevertheless there is a difference between the kind of representation adopted by the Cabri-files and the conventional representational rules of Optics: in Cabri-files rays are represented by lines without arrows, when optical rays carry arrows to indicate the direction of light propagation.

5.1.b. Teacher's discourse analysis during the session

The teacher's discourse allows us hypothesising that the teacher aimed at making a link between the two worlds. We base this interpretation on the observed identification of some elements of the world of objects and events (the crystalline lens, the pupil, the retina, all specified by the "drawing", figure 1) to corresponding elements of the world of theories and models: the lens, the opening in the square, the screen on the bottom of the square (figure 2).

In his discourse, the teacher tried to explain a phenomenon of everyday life (the accommodation) through a physical model. He suggested the situation belonging to the world of objects / events for students ("*Probably you noticed it when you are reading your textbook or a book, and you look at suddenly something far from you*") and then produced his explanation.

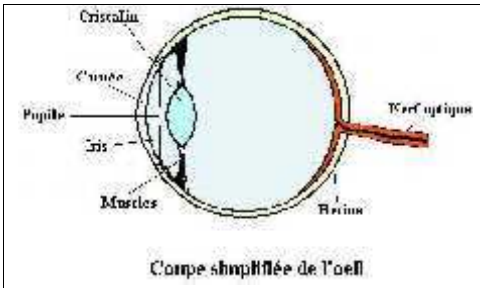

Figure 1: static representation of an eye.

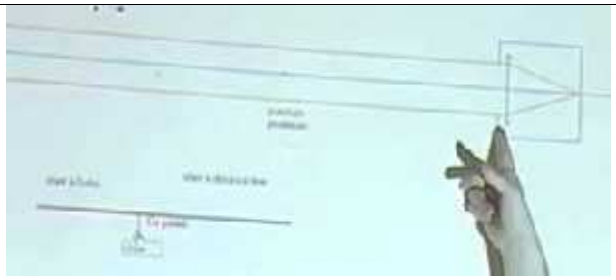

Figure 2: dynamic representation of an eye, from a physics point of view; representation obtained by Cabri software; case of an object at an infinite distance from the eye.

5.2. Analysis in terms of semiotic registers

The teacher made explicit for students the difference between two semiotic registers: the graphic representation and the drawing (saying for example: *you see here is a schema, it is a schematic representation, not a drawing like what we saw last week*). Nevertheless this distinction is limited because these two kinds of representation were not present simultaneously.

Through his gestures when projecting the Cabri figure, the teacher has provided links between two semiotic registers: the schematic register and the register of natural language. In fact, the teacher pointed with his finger relevant elements on the representation; for the converging lens for example he said: "*light rays as they pass through the lens as they are all converging lens ....*" (figures 2 and 3).

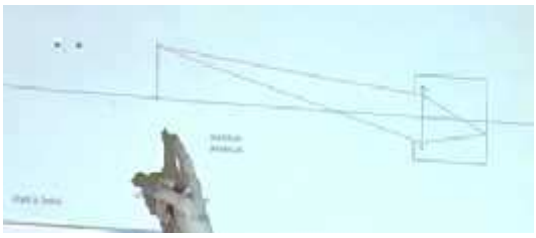

Figure 3: dynamic representation of an eye, from a physics point of view (representation obtained by Cabri software; case of an object at a finite distance from the eye).

5.3. Analysis in terms of learning opportunity

Using Cabri-géomètre, the teacher introduced a temporality to explain the convergence of a light beam after passing through a converging lens. The convergence of light may appear to be stationary (stable) when students carried out an experiment with a light and a converging lens. The use of Cabri by the teacher allows students observing the phenomenon in two phases: the light rays before crossing the lens (first phase) and the light rays after passing through the lens (second phase).
The use of a Cabri file offers to students the opportunity to visualise, for the first time, the modelling of the image obtained by a convergent lens in the case of an object at a finite distance from the lens (figure 3). The teacher gave here a new learning opportunity to students, characterised by the fact that the image is formed on the retina of the eye, whatever can be the place of the object relatively to the lens.

5.4. Analysis in terms of coherence

At many occasions during these five minutes, the teacher refered to the previous activities performed the week before by students ("*you remember*"): he recalled the experiment showing that the image through a converging lens is located in a special place behind the lens (fourth activity); but he also indicated that the situation is different for the image formation on the retina (the screen does not move), and that is his way to introduce the changes in the focal length of the crystalline, the accommodation phenomenon. Moreover he made the parallelism between the fifth activity (the schema of the eye) and the modelling of an eye in the Cabri-environment.

6. CONCLUSION

In this episode, we can observe that the meaningful articulation between the semiotic registers, the modelling levels, the activities of the sequence, allowed to this experimented teacher offering new learning opportunities to students (such as the link between their everyday life experience and the accommodation phenomenon), and strengthening the learning opportunities which had been offered in the previous sessions (like the fact that the optical image is formed in a located area behind the lens).

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