The knowledge in postlab sessions

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• Introduction and theoretical framework

Although several decades of research in chemical education have stressed on the importance of experimental activities in learning, there is still no widely accepted theory of instruction or carefully thought out manageable methods of implementation consistent with constructivist theory (Williams and Hmelo; 1998 p. 266). It has been recognized that laboratory activities have the potential to enhance constructive social relationships as well as positive attitudes and cognitive growth (Hofstein & Lunetta 2002), but mismatches often occur between teachers' perceived goals for practical work and students' perceptions of such activities (Hodson, 1993, 2001; Wilkenson & Ward, 1997). Laboratory sessions cannot by themselves be in charge of the whole learning, even if they have been carefully designed, and teachers should consider that learning can be helped with pre- and postlab reporting and discussion.

For the last 15 years, our group has been involved in the design of teaching sequences (Buty et al. 2004) the characteristics of which are to make explicit the relations between the objects that are manipulated, the events that are observed and the models that are the goal of the teaching. While integrating other metacognitive learning experiences such as "predict–explain–observe" demonstrations, etc. (White & Gunstone, 1992) laboratory work must incorporate the manipulation of ideas instead of simply materials and procedures and are hoped to promote the learning of science.

Although research data show that students seem to profit from such experimental session in relating the experimental field with the world of theory and model (Tiberghien, 1994), teachers express difficulties in being comfortable with laboratory work designed at such. Our hypothesis is that the knowledge is not presented in a well structured and formal manner as it used to be with a classical transmissive teaching. The knowledge is actually involved during the laboratory sessions but as Chang and Lederman (1994) and others (e.g. Wilkenson & Ward, 1997) have found, students do not have clear ideas about the general or specific purposes for their work in science laboratory activities and therefore are not conscious that they do manipulate the knowledge to be learned. The knowledge to be taught involved in a lab and postlab sessions will be the core of our research and will structure the analysis of our data. The status of the knowledge during teaching as it is described in the methodology (see below) will characterise the teaching situations.

• Research questions

The aim of this research project is to better understand the way knowledge is at work during the postlab sessions during which teachers have the opportunity to point out the relevant knowledge that has been used during the laboratory session. We agree with Polman's claim (1999) that to foster science learning through projects and inquiry, teachers must play a complex role. But which role? Once we will be able to describe the postlab sessions, it will be possible to make hypothesis on their improvements and measure their effects on learning. This description is to be based on three axes: (i) the knowledge to be taught, (ii) the interactions between the teacher and the students and (iii) the objects (glassware, chemicals, texts) involved during the postlab session. Our research questions can be formulated as such: How can the status of the knowledge describe the kinds of phases organised (consciously or not) by the teacher? What kind of information does/can the teacher use during postlab sessions? Which parameters that describe postlab sessions may influence learning?

• Method

A pilot study has been realized by videoing one postlab session of an experimented teacher in the second year of upper secondary school. It allowed us to improve our method for a larger study with more sessions and more teachers, although we will still keep with case studies. Six postlab sessions with three different teachers are to be videoed between December 2005 and May 2006 at the first year of upper secondary school. The three teaching sequences that will be taught have been designed and improved in our research group with experimented teachers during the last ten years but postlab sessions have not been be studied yet, nor it seems to have been in the literature. The first sequence deals with structural study of matter (atoms, chemical elements and molecules), the second introduces the amount of substance and the concentration, and the last is a first approach of the chemical reaction with their microscopic and quantitative descriptions. The three teachers have been teaching for 3, 7 and 19 years and represent a wide spectrum of teaching experience.

The students' lab reports and their assessments that will end each teaching sequence will also be collected. The amount of these quantitative resources will be about 50 reports and 100 assessments per postlab session as students work by pairs during the laboratory sessions but are individually assessed.

The videos are the main data of this research and will be analyzed as follow:

1st axis of analysis: the knowledge to be taught – The analysis of the transcripts of the video of the teachers during the postlab sessions will consider the status of a given knowledge (to be taught during this teaching sequence) in the interactions between the teacher and the students. Four kinds of phases have so far been observed in our pilot study:

(i) When *this* knowledge is being put into words that are understandable by the teacher and the students, the phase is said to be a "wording-phase". Being able to have words going along with a piece of knowledge is an important step of learning.

(ii) Another status for the knowledge is to be validated, justified, etc.; the phase is said to be a "justification-phase". The issue of such a phase requires that the students and the teacher agree on a reference to base their validation on.

(iii) The use of a piece of knowledge in a given context is expected to be a frequent phase of postlab session. Such a phase is called "contextualisation".

(iv) The last status of a piece of knowledge is called a "generalisation" and occurs when it is decided that the knowledge will be used as a reference for future situations. The teacher is most of the case in charge of such a phase. The teacher as a member of the teaching institution is in charge of establishing the new status of this knowledge. As Driver (1995) said: "If students' understandings are to be changed toward those of accepted science, then intervention and negotiation with an authority, usually a teacher, is essential".

2nd axis of analysis: the interaction between the teacher and the students – The teacher and students' interactions through which the knowledge is exchanged may have occurred during the laboratory session, may be through the students' laboratory reports or can take place "live" during the postlab session. Such interactions may inform us on the origin of the information the teacher uses to take decisions during the postlab session or how s/he organises it.

3rd axis of analysis: the materials involved during teaching – These materials can be textual or not. Among textual material we will consider the permanent ones (sheets of paper, copybooks, books) and non permanent ones (blackboard, screen of computers, etc.). We believe that of the permanent character of the text of the knowledge may strongly influence

teaching and learning during postlab sessions. Permanent texts can be used in the future by teachers as references where as non permanent ones are expected to have different roles.
The effectiveness of the postlab sessions will be measured by comparing the knowledge as it appears in the students' laboratory reports to the knowledge as it is assessed at the end of the teaching sequence. We hypothesis that the postlab sessions are a key factor in the students' understanding and that changes that we could operate during an attempt of an improvement of a postlab session would provoke visible effects in the assessment.

• Preliminary results

The pilot study showed the validity of the method for the analysis of the video of one postlab session. The number interventions (teacher + students) of each category are given in the following table.

Categories	Knowledge to be taught				Other chemical knowledge				Calculus	Appreciation	Other
	W	J	C	G	W	J	C	G			
N = 258	35	12	7	5	45	5	3	3	20	19	104
%	22,9				21,7				7,8	7,4	40,2

Table 1 – Number of interventions per categories. W = wording phase; J = justification phase; C = contextualisation phase; G = generalisation phase. The "Appreciation" column corresponds to the teacher's recognition of the qualities and the faults of the students' reports.

The data in the table show that the teacher spent less than 25% of the time on the knowledge to be taught during the post lab session and most of this time is devoted to wording. We hope to be able to study the effect of parameters such as the time on each category on students' learning. We expect that our study will point on important factors that may optimize the effectiveness of postlab sessions. The usefulness of laboratory work could therefore be improved. Our results would therefore be highly valuable for teacher training as we lack data to convince teachers of the importance of a socio-constructivism approach in teaching during laboratory work involving ideas more than materials or procedures.

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