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Teacher activities for structuring student knowledge after chemistry laboratory work

Rita Khanfour-Armalé et Jean François Le Maréchal

Introduction

Laboratory activities have the potential to enhance constructive social relationships as well as positive attitudes and cognitive growth (Hofstein & Lunetta 1982), but they can not govern the overall learning process. One of the reasons is that students do not have clear ideas about the general or specific purposes for their work in science laboratory activities (Chang & Lederman, 1994). As a result, during laboratory activities, students involve the knowledge that is to be learned, but also incorrect knowledge (within observations and interpretations) without being aware of it. Teacher intervention is therefore necessary in order to point out the correct and the incorrect knowledge, to formulate and to structure it. As only a few teacher interventions occur during the laboratory sessions, a moment where the teacher can come back to the knowledge to be learned must be planned during the teaching sequence. A way to enter more deeply into the learning process is therefore to analyse a class discussion during this “come back”. It might involve linguistic tools for structuring the discussion as well as didactic tools to specifically understand and compare the knowledge imbedded into the teacher-class interaction. The aim of our research has been to provide a new insight into these moments occurring after profitable experimental activities. We have given the name of “debriefings” to these moments. During a debriefing, the teacher takes back the responsibility of organizing the knowledge after having let his/her students be autonomous during the laboratory work. We consider that these moments are debriefings only if the teacher comes back to the concepts imbedded in the activity within the same context as the experimental situations.

We consider that knowledge in class can be reconstructed from examining the teacher-class interaction. This interaction has been analysed from two perspectives: a linguistic analysis based on ternary exchange (Lemke, 1990; Manzoni-de-Almeida, and al.2014) and a didactical one based on a division of knowledge into facets (Minstrell, 1992). In the linguistic analysis, whether it is a dialog between a teacher and his/her class. The basic structure of the conversation can be viewed as a ternary exchange where a first speaker initiates the discussion, the second one answers, and the first one evaluates the answer. This sequence currently noted I-A-E has been observed in class discussions (Mortimer, 1998). Deviations from this basic ternary exchange are interesting to understand, as are the characteristic of the interactions – we have, for example, compared their lengths. The division of knowledge from a facet perspective allows it to compare the knowledge involved in the interactions of different situations. Facets are units of knowledge that are reconstructed from utterances. For comparisons between different situations to be possible, this reconstruction has to respect the idea carried along by the utterance, and include a generalization of contextual words.

What are the possible class organisations to debrief laboratory activities and how is it possible to characterize them in terms of their linguistic structure and scientific content?

Methodology

Our main source of data is a corpus of 35 class videos recorded with the camera focused on the teacher. Five teachers were observed as they were debriefing experimental activities at the upper secondary level in chemistry classes. These activities were drawn from a pool of nine; most of them had been designed during meetings between these teachers and our research group. The conversations between teachers and their class were transcribed. In one hand, the

transcriptions were split into ternary exchanges. The initiative interventions of ternary exchange were compared to the questions of the text of the laboratory work. In the other hand, facets of knowledge were extracted from the teachers' and students' utterances where *sensitive* concepts were involved (a concept is said to be *sensitive* when the teacher has a learning objective regarding this concept).

Results

Our analyses led us to consider three kinds of debriefings: feedback debriefing, summary debriefing and lecture debriefing. For all of them, the teachers were back in charge of the knowledge to be taught. They used the same sensitive concepts as those the students had used during the laboratory work, and in the same context.

Feedback debriefing is by far the most observed practice (30/35). During such a debriefing, the teacher has in his/her hands the text the students had worked with, and s/he reviews most of the items in the same order. The class discussion is most often (81%) structured as ternary exchanges, with the teacher's questions serving as initiators for interaction. These questions have been categorized as text questions if they belong to the text of the laboratory task (22.7%, $N = 366$), and non-text questions (77.3%). For the latter, 44.8% deal with the context of the experiment, 5.6% are meta-questions (reflections about the knowledge), 5.4% are based on relations between different text questions and 3.9% are given as simplifications of a text question. This categorisation left over 17.6% of uncategorised questions that are mainly continuity interventions such as: "and then?" or "what else?" to incite the student to keep on talking.

Student interventions were categorised in terms of I-A-E. Most of them were A (97%), a few were I. The former category often dealt with observations or interpretations.

After the teacher's initiations and the students' answers, the teacher's evaluations were categorized. The most frequent E-interventions were formulations. A formulation could be a teacher's repetition or reformulation of the student's answer (57%, $N = 791$, there could also be more than one category of evaluation per ternary exchange). The teacher could also deal with the knowledge imbedded in the student's answer (26%), contextualise it (11 %) or generalise it (6 %).

Summary debriefings are organised around a document that the teacher gives to pupils, with a summary of the knowledge to be learned. The facets of knowledge were found to be the same in the summary and in the corresponding experimental activities. Only 3 summary debriefings were found out of 35, but when asked about their practices, teachers sent us 4 other summaries that had been used in debriefing conditions. Such a debriefing is therefore not as rare as the analysis of our corpus might suggest.

In the summary, experiments may be compared (thin layer chromatography / column chromatography). Teachers may also hinge sensitive concepts introduced in different lessons (Lewis representation / Cram representation). One of these courses may be the following in the teaching sequence.

In lecture debriefings, teachers develop a structured presentation of the knowledge that includes the sensitive concepts of the laboratory work and present it to the class. We observed only two lecture debriefings. In the first one, the organisation of the knowledge was the same as the one of the laboratory work, with the addition of a few extra examples and topics. In the second one, the organisation of the knowledge was different. Much more facets were used in these debriefings than in their corresponding laboratory sessions (66 vs. 8 in one case and 54 vs. 10 in the other one). The link between the laboratory work and the debriefing came from several examples of the former that were introduced in the latter.

Conclusion and discussion

In the feedback, the teachers spend little time with generalisation and contextualisation (prime importance in science teaching). Moreover, they spend little time in asking questions that could be cognitively motivating (relation, meta), or helpful (simplification). These data are in agreement with the fact that students often get bored during such debriefings; when we recorded the videos, students did not pay much attention to the teacher unless they were requested and produced a background noise. In addition, teachers feel uncomfortable with feedback debriefing. When interviewed about the reasons for doing it, they said that they felt obliged to come back to the activity they had proposed to the class and that this format is easy to work with.

One of the aims of the summary is to provide the students with a written record, whereas during feedback debriefing, most, if not all, courses are oral. In the summary, the language is more formal and complex than during the oral discourse of the feedback debriefing. We found that the summary was commented in relation to the experiment done in class, or just assigned as homework.

Unlike the feedback debriefings, as it happened, students took the initiative in ternary exchanges and asked questions (25 in one case and 45 in the other one). These students' attitudes show their motivation in and interests for lecture debriefings. The linguistic structure was different from the one observed for other types of debriefing. Half of the ternary exchanges were interrupted by a long comment by the teacher. This comment was neither an evaluation of the previous exchange, nor an initiative toward the following exchange. We called this comment counter-exchange. The density of facets was higher during the counter exchange than at any other moment of the debriefings (50% of the facets attributed to the teacher during the debriefing).

Our research has been able to provide an understanding of the way teachers come back to an experimental activity. Such an understanding may help to improve novice teachers' practices as our feeling is that they will spontaneously adopt feedback-type debriefing. The efficiency of these three teachers' practice remains to be evaluated. We already proved that from the content measured in terms of facets, the lecture is more effective than the summary and the feedback. The lecture also provides more student motivation than the feedback.

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