Students' adaptation to a new situation: the design of an experimental procedure

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1- Background, aims and framework

Different studies (Arce and Betancourt, 1997; Séré, 2002) emphasize the importance of the task of experimental procedure design in a learning context. However, the required design is a difficult task for students (Séré and Beney, 1997). Consequently, students are hardly ever allowed to design their own experiment. The study by Tiberghien *et al.* (2001) showed that "to learn how to plan an investigation in order to address a specific question or problem" was the least frequent process objective. Although this paper does not focus on direct learning gains, there are reasons to believe that design activities contribute to learning (Hmelo *et al.*, 2000).

During a labwork session, students were asked to design an experiment. The aim of this research is to analyse the changes in the students' activity when they have to design an experiment and observe how they handle with these changes. In this paper we will first characterize the situation and then analyse the adaptation to this new situation.

2- Methods and samples

In association with two high school teachers, we designed a labwork situation in which students were asked to determine by spectrophotometry the predominance's diagram of Bromothymol Blue (BTB), in order to determine precisely its pKa. The corresponding model was given (Figure 1) and the students had to design an experiment to verify this model by the experience. They had to write down the detailed experimental procedure they will follow, before executing the procedure.

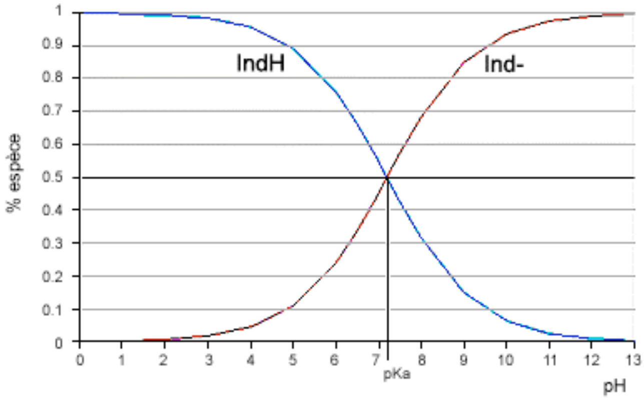

Figure 1: predominance diagram of acidic (IndH) and basic (Ind-) species of BTB, related to the pH.

In this research, 65 French students aged 17-18 of the last year of secondary education (ISCED 3A level, scientific orientation) participated. The students belonged to two French high schools. Each classroom was divided in two groups, students working by small groups of trinomials (23 trinomials). A preliminary course (prelab) was dedicated to the introduction to the lab and the model: corresponding spectrophotometric spectra were analyzed to understand how the data need to be processed. The lab lasted two hours. We collected the students' written documents and recorded their conversations.

The situation was analysed in terms of tasks to be done and concepts to be mobilised by the students. A task tree was used to model the tasks and to determine what would be devoted to students. This tree also allowed to analyse the students' written procedure (tasks and parameters). This kind of tree organisation refers to a downward analysis of a problem, well known in computer programming (Wajeman *et al*., 2005). The initial question to solve through the experiment was divided in main tasks and sub-tasks. Each task was related to the concepts necessary to solve the problem.
We also characterised and analysed the situation, using the Brousseau's theory of didactical situations in Mathematics (Brousseau, 1997). He characterises the situation related to the « milieu » (everything that acts on the student or that the situation acts on).

3- Results and discussion

3.1 Characterisation of the situation

This corresponds to the choices we made when we designed the activity. We designed a task tree dedicated to this labwork. While they designed the experiment, the students had information from the « milieu »: they could see the equipment on the bench, they had access to different written information such as the user guide for spectrophotometer, the user guide for the pHmeter, the labsheet which provides the model and technical information and the prelab document. We have been able to relate these elements to the tasks and conclude that the « milieu » gave at least one information for each task and most of the sub-tasks.

3.2 Adaptation to the new situation

Design of the procedure
In order to design the experimental procedure, students had to decide what they had to do, i.e. define the task, precise how they would do it, which equipment would be used, and specify the parameters. This was a break with the established didactical contract (Brousseau, 1997).
The results show that some students did not analyse correctly the situation and would refer to another situation that is probably more common for them We give an example related to the question of the precision. In order to plot a non linear curve, the expert strategy is to prepare more solutions when the curve rises quickly. No group used this more precise strategy. Most trinomials (19/23) referred to a linear curve, a more common situation in science and specifically in mathematics, but not appropriate in this case. We noticed that the problem of the precision is usually devoted to the teacher.

Writing of the procedure
Students had to plan the procedure but what did they write? The instruction was to write down any information that seemed important so that the procedure is complete. The results showed that the students did not write the entire procedure as we expected.

- The students wrote mainly what they designed themselves and did not write what was already discussed with the teacher. For example, very few trinomials (4/23) specified the wavelength corresponding to the absorbance they plan to measure. The reason might be because this wavelength was chosen during the prelab.
- The students did not write what they master. For example the task « introduce a precise amount of solution in a container » is detailed by only 1 trinomial out of 23. This task is a basic one in chemistry and well known at this level of study.
- The students also did not detail what is already written elsewhere, even if this task was not well known. For example the task « determine the absorbance of the solution » is mentioned in the procedure by 20 trinomials, but detailed by very few groups (6/23). They only used once before a spectrophotometer, but they had a written reference procedure during their first spectrophotometer lab.

- They did not correct the written procedure if they changed it during the execution. For a specific task, 6/23 groups did not execute what they wrote and only 1 of these 6 groups modified the procedure afterwards. We did not expect this result, because the instruction was to modify the written procedure if necessary once they applied it.

The written procedure seemed to be a draft for students. They would only write ideas to remember before proceeding.

4- Conclusions and implications

Students were in a new situation which corresponded to an important modification of the didactical contract. In some cases, they did not analyse correctly the situation and referred to a non appropriate strategy. Designing an experiment is an interesting way to ask students to think and act as experts. When faced to a difficult lab as this one, the teacher could take in charge part of the work and identify some tasks devoted to students. This implies to think about the guidance (Kirschner *et al*, 2006).

We also identified problems regarding the writing of the procedure. They did not write what we call a procedure, but rather a draft. If we refer once again to the Bousseau theory, the formulation phase was is in favour of talks between the students but did not oblige them to put their talk in words. We believe that it is important to find another way to push them to detail the procedure, such as giving the written procedure to other students in order to apply it. Such experiment was realized in a biology labwork and gave interesting results (Marzin *et al*, submitted).

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