10 COMPARATIVE ANALYSIS OF THE ACTIVITY OF TWO TEACHERS IN TERMS OF PUPIL'S ACCULTURATION TO SCIENCE

Patricia Schneeberger[1], Yann Lhoste[1] and Brigitte Peterfalvi[1]
[1] Univ. Bordeaux, ESPE d'Aquitaine, E3D / LACES (EA 4140), France
patricia.schneeberger@espe-aquitaine.fr
yann.lhoste@espe-aquitaine.fr
brigitpeter@hotmail.com

Abstract

French curriculum places great emphasis on problem-based learning because scientific problems are supposed to have an essential part in the construction of scientific concepts. For researchers in didactics, the students' appropriation of scientific problems is necessary to allow them to start assimilating scientific culture and to build knowledge.

In this paper, we study how two teachers (a student and an experienced teacher) conduct a phase of problem building involved in acculturation to science.

In the analysis of the teachers' actions during those sessions, we identified two kinds of sequences: times of convergence and times of divergence. During the phases of convergence, the teacher's actions (through problems building and solving) engage students in a process of acculturation to scientific ways of knowing, whereas during the phases of divergence, the teacher's actions, even if they stick to the topic, don't support this process but aim to fulfill other requirements of school teaching. We found that the occasions of convergence were more numerous in the session led by the inexperienced teacher, while those of divergence were more common in the session led by the experienced teacher. Our study tries to identify the differences between the two teachers and to explain their source.

Keywords: Acculturation to science, professional gestures, language interactions, problem-based learning

1. Introduction

The renovation of the teaching of science has led to the promotion of a form of science education based on the scientific inquiry model. It is important to realize that scientific problems differ from everyday ones. The process of scientific inquiry, as described in the French curriculum, places great emphasis on those scientific problems because they are supposed to have an essential part in the construction of scientific concepts. For researchers in didactics, the students' appropriation of scientific problems is necessary to allow them to start assimilating scientific culture and to build knowledge.

In the following article, we study how teachers can take into account this consideration, particularly in debates proposed to students.

For this purpose, we compare the actions of two teachers, an inexperienced teacher (a student in the second year of her postgraduate master's degree) and an experienced teacher, when conducting a phase of problem building during a scientific debate. The aim of this study is not to compare their respective skills, but to show how they allow students to construct the involved knowledge and then to identify the professional practices that facilitate the construction of knowledge in science teaching.

2. Theoretical framework

Our study uses a double theoretical framework

- The rationalist tradition of science education, which considers that there is an epistemological rupture between everyday knowledge and scientific knowledge (Bachelard, 1938; Canguilhem, 1965; Popper, 1972) ;
- The socio-historical approach to learning, which considers that schooling should allow students to acquire the knowledge that is specific to scientific culture and ways of thinking, talking and doing associated with that knowledge (Vygotsky, 1986; Brossard, 2004).

The rationalist tradition of scientific activity emphasizes the importance of to the construction of scientific problems, rather than their resolution and thus their solution (Bachelard, 1938: "*the meaning of the problem is the true mark of the scientific spirit*"). This leads us to examines how speech acts of the teacher do or don't enable students to appropriate scientific problems involved in the situations they set forth. Through the analysis of the practice of each teacher, we try to understand how they manage the construction work of the problem by the students.

Members of the scientific community share very specific ways of thinking, talking and doing with which the knowledge constructed by the scientific community is very deeply connected. According to our theoretical framework (socio-historical approach to learning), we consider that schooling should allow students to acquire not only this knowledge but also these ways of thinking, talking and doing. We call acculturation the process by which students are introduced to this culture.

Our previous studies have shown that students' appropriation of scientific problems is necessary to start assimilating scientific culture and to build knowledge. In a social perspective on learning, the challenge lies in helping learners to achieve this process of acculturation successfully in the classroom. According to Driver and al. (1994), the teacher's intervention is essential.

3. Key objectives

Our purpose is to understand, thanks to a comparative method, how two teachers, whose experience is very different, go about facilitating the construction of a scientific problem by the pupils so as to engage them in a process of acculturation to science.

One of them, inexperienced, had very recently been studying the teaching and learning of Natural Science and so, before constructing the session focused on nutrition, she had already conducted a reflective work in didactics. The session carried out by that novice teacher was then analyzed with her supervisor in order to write her master's assignment. The other one, an experienced teacher, had implemented a similar session, which had been prepared by the inexperienced teacher.

We will try to associate the results of our analysis in respect of the experience of each teacher.

Our research questions are the following:

1. How and why a teacher's actions do or do not enable students to appropriate scientific ways of knowing?
2. Which actions promote the construction of a scientific problem in the classroom and what those which delay it?

4. Research design and method

4.1 The educational project

Both sessions took place in two primary school classes (10 year-old pupils).

The starting point of the session was: *"How does the grass eaten by the rabbit enable it to form bones, muscles, etc?"*. The pupils had to complete a drawing (Figure 1) and indicate the connection between the physical development of a rabbit and the food it eats. Then a debate took place, using the comparisons of the posters produces by the working groups.

The proposed situation potentially contains the problem of distribution because the drawing shows the distance between the digestive tract (where the food goes after eating) and the organs which grow (muscles, bones)

On the topic of nutrition, we can identify two categories of recurrent problems that arise in different forms and different formulations according to educational levels:

- The first problems concern the issues of absorption and of distribution: foods or nutrients have to leave, one way or another, the digestive tract to reach different parts of the body.
- The second ones concern the problem of assimilation: how can living beings produce their own material from what they gather from the surroundings? Both issues are present in the primary, middle and high school curriculums.

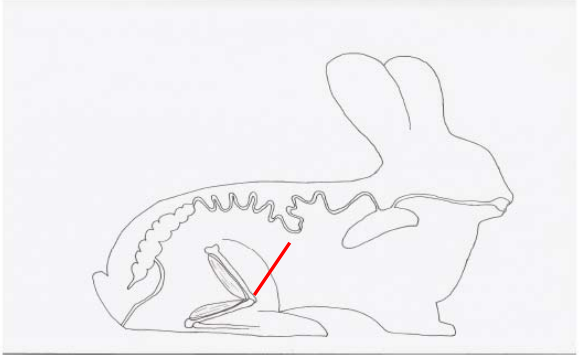


Figure 1. The drawing pupils have to complete.

The red line between the digestive track and the bone of the leg didn't appear on the drawing that the students had to complete; it had been added here in order to show the distance between the two parts of the rabbit which have to be somehow joined for a comprehension of the function of nutrition.

Students have to understand the need of a distribution of nutrients to fill the gap that exists in the diagram between the digestive tract (represented by a pipe without holes) and organs.

4.2 Corpus

Both teachers have been voluntarily chosen because of the contrasts in terms of their professional experience and their working conditions. The inexperienced teacher designed the session as part of its research work (for her MASTER assignment) on the problem building in science. During her training, she studied the concept of problematization through many articles. She implemented her device in a class of 24 students during an internship included in her training (3 weeks).The experienced teacher implemented the device from the elements of preparation of the student who had also provided research articles on the subject (Lhoste & Peterfalvi, 2009). The sequence took place in his class year (19 students). We observed the teachers' speech acts.

We collected data in the two classes during the first four sessions of the sequence on animal nutrition:

- a diagnostic evaluation session;
- a working session in homogeneous groups (students with similar representations) where they were asked to produce a poster (same task as the one proposed in the diagnostic evaluation);
- two sessions of scientific debate.

The following sessions (working on documents and conclusion) have not resulted in a collection of data in light of our research questions.

The corpus is composed of different materials:

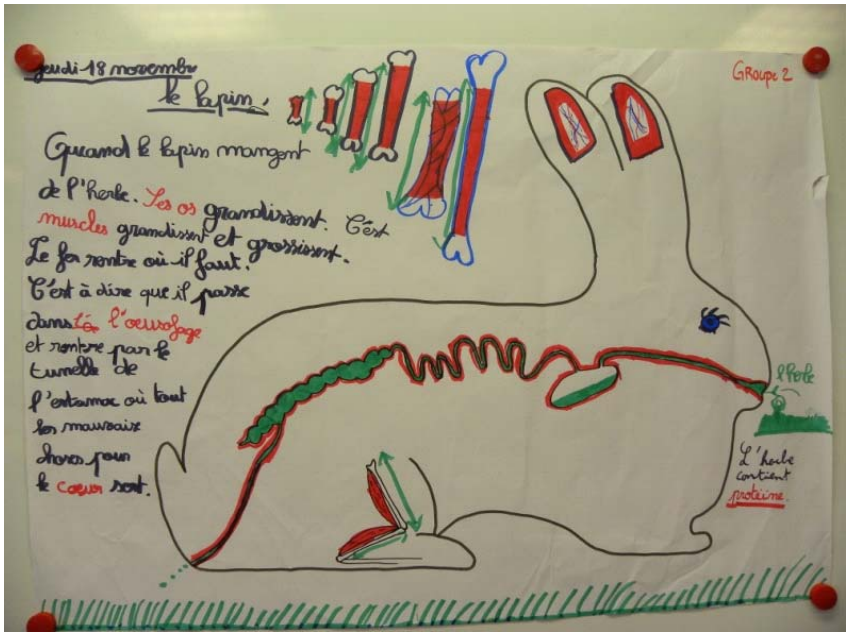
- The preparatory document for the session which is aimed at the appropriation of scientific problems by the students, made by the inexperienced teacher and then used by both the inexperienced teacher and the experienced one to implement a similar session.
- All the written work of students, posters produced by the working groups (Figure 2) and class posters.
- Transcripts of the video recordings of the 2 sessions.

The preparatory document for the session

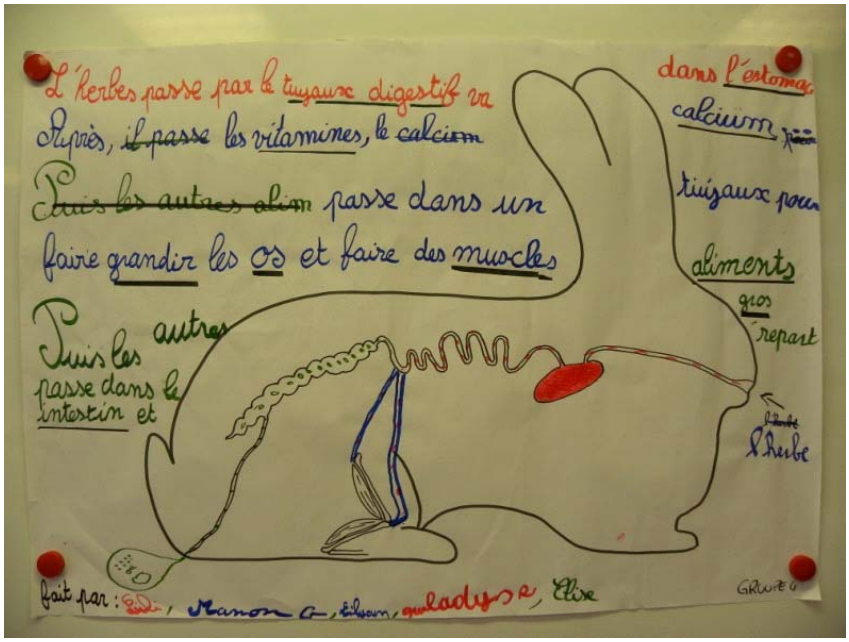
We can already notice some ambiguities or implicit contents inside this document, which can explain that the experienced teacher didn't always understand the aim of what the inexperienced one planned to achieve in the session. The inexperienced teacher tried to anticipate the obstacles to be overcome to help pupils understand nutrition (Clément, 1991). However, the obstacle corresponding to the idea of a sealed pipe representing the digestive tract is not clearly expressed in this document (Clément, 1991). Therefore, while the novice teacher focused the debate on the issue of absorption, the experienced teacher obviously did not take the importance of the work on this obstacle into account.

Table 1. Excerpt of the preparatory document

Study Theme	**Nutrition**
The object of study	Supplying organs with nutrients that can enable the production of matter specific to the individual
The problem studied	The production of material from the supply
Obstacles	The body is a closed bag - Existence of two pipes, one for the liquid and the other for the material - Foods remain trapped in a sealed tube - "What is good or bad" - circulation of blood: unclosed circuit
Proficiency in its productive dimension: the performance objective	Students should be able to: - report the transit of the food (specific) in the digestive tract and their transformation into non-specific nutrients - Explain that nutrients must be absorbed in order to pass into the blood - Explain the distribution of these nutrients throughout the body via a closed circuit
Competence in its constructive dimension: the goal of transformation	Transformation of the food into a nutrient through a mechanical action in connection with a chemical action to change its specific nature into a nonspecific one, the mechanical action facilitating the chemical action - specific and characteristic wall, notion of sorting out: processed and unprocessed - Exchange surface with the blood, moving from the idea of a pipe to the idea of a closed circuit
Learning content or the conditions of transformation	Awareness of the need for assimilation to develop, hence a need for distribution, absorption made possible through the food processing through mechanical and chemical action.



When the rabbit eats grass, its bones get bigger, its muscles grow and get bigger. The iron enters where it has to. I.e. it passes through the esophagus and enters through the tunnel of the stomach where all the bad things for the heart go out.



The grass passes by the digestive pipe, goes into the stomach. After ~~it passes~~ the vitamins, calcium,...
~~And the other food~~ passes through a pipe to make bones grow and make muscles. And the other food passes into the large intestine and goes out.

Figure 2. Examples of drawings produced by two of the working groups.

4.3 Methods

We made a microscopic analysis (of each student's proposal) to show the construction of knowledge in relation to our epistemological analysis (*a priori* analysis which allows us to identify: ingredients of the object of knowledge, relationships between these ingredients etc…). Then we analyzed the teachers' linguistic action that prompted the students' proposals.

Divergence and convergence are defined by the following features :

- Convergence refers to the trace of the construction of the object of knowledge by students. The teacher' interventions help the construction of the object of knowledge.
- Divergence refers to the trace of the construction of the object of knowledge by students. The teacher' interventions of are not in line with the continuation of this construction.

Then, we categorized the teacher's speech acts during the moments of convergence and divergence.

In order to identify how pupils engage in a process of acculturation to science from the viewpoint above-mentionned, we analyzed the transcripts of the 2 sessions, using a didactical analysis combining two approaches, focused on linguistics and on the construction of scientific problems (Lhoste 2008; Lhoste & Schneeberger, 2009; Schneeberger & Vérin, 2009).
We analyzed the specific actions of each teacher that enabled this process to be initiated.

5. Examples of our analyzes

In the analysis of the teachers' actions during those sessions, we identified two kinds of sequences: times of convergence and times of divergence. During the convergence phases, the teacher's actions focus on the process of problem building, whereas during the divergence phases, the teacher's actions, even if they stick to the point, express a tension between this aim and other concerns.

5.1 Two moments of convergence

Script 1 below deals with the problems of the distribution and absorption of nutrients.

The analysis of the debate transcript shows how pupils engage in identifying the problem thanks to their teacher's help.

In 37 ("*So the mixture goes into the blood*?"), the teacher selects from Manon's proposition (her explanatory model, her "solution"?) something that focuses the pupil's discussion on the problem of distribution. That discussion could potentially start working about the obstacle. In 42 (Elise: *And how will the vitamins go to the muscles and bones?)*, we can observe the first identification of the scientific problem by the pupils. Elise is proposing a sort of formulation of the problem of distribution / absorption, but she doesn't give the reason why that is a problem: a priori, it is not plausible because we don't see how it would be possible to go through the intestine.

In 43 (the key moment on which we now focus our attention), the teacher repeats that formulation and writes it on the blackboard. That professional act (writing a sentence proposed by a pupil on the blackboard) is in keeping with the progress of the pupils by

identifying the problem, but in a special way. What is written is a question. It changes the status of this question, which becomes a question to be solved by the whole class. This common professional gesture supports the specific process of construction of the problem of distribution / absorption which is now clear for the whole class. That constitutes an example of what we call "convergence". During that exchange, and in what follows, we can see how pupils gradually identify the problem of distribution / absorption that was potentially indicated in the starting situation (the digestive tract is away from the organs).

Script 1. A moment of convergence (inexperienced teacher).

36 – Manon*: Actually, when the rabbit eats, the blood flows up around the ears so that the mixture well,... it goes into the blood*
37 – Teacher: *So the mixture goes into the blood?*
38 – Manon: *Well, actually it's the grass that goes into the body, it eats grass and then crushes it (the grass).*
39 – Teacher: *Okay that makes a mixture and the mixture goes into the blood.*
40 – Manon: *That's it.*
41 – Teacher: *Other questions?*
42 – Elise: *And how will the vitamins go to the muscles and bones?*
43 – Teacher (writing on the board): *How will the vitamins go to the skin and muscles?*
44 – Manon: *Well, you you take orange juice in the morning, ah you don't, there are vitamins in fruit, and stuff, there are vitamins. And inside... there is a kind of little product and it makes the rabbit develop.*
45 – A pupil: *The root.*
46 – Manon: *Yes.*
47 – Lili: *What did you draw for it to make the bones grow, because…*
48 – Davy: *Yeah, we can't see very well.*
49 – Manon doesn't answer.
50 – xxx (inaudible)
51 – Teacher: *In fact what Lili is asking you, is what makes the rabbit grow if the grass is here and it grows there.* (She shows the intestines of the rabbit and the place of muscles and bones).
52 – *Manon: is mulling it over but does not answer*
53 – Teacher: *There was no answer. She shows their explanation. But it does not matter we cannot answer all at once.*
54 – A pupil*: If this is the mixture that passes through the gut, how come everything passes in the blood like that?*
55 – Teacher: *Yeah, well that's the question that they did not answer in their poster. We will try to see with the second group if they provide an explanation. We will write your question and you'll try to reformulate it.*
56 – Bryan: *How can a big mixture pass through the organ like that?*
57 – Luci: *How does the mixture go into the blood?*

So, by this convergent act, the teacher entered a formulation of the problem to provide a starting point for further research).

Gradually the problem is made more precise and takes on the collective status of a problem to be solved. In 47 (student: "*What did you draw for it to make the bones grow, because...");* 51 (teacher: "In fact what Lili is asking you, is what makes the rabbit grow if the grass is here and it grows there". She shows the intestines of the rabbit and the place of muscles and bones) in 53 (teacher: "there was no answer"); in 54 (pupil:" *If this is the mixture that passes through the gut, how it is that everything passes in the blood like that?*"); in 55 (teacher: "this is the problem to which we don't have an answer yet"); in 56 and 57 (pupils reformulate the problem as a puzzle taking the sieve as a model to solve it). The general professional gesture (writing a pupil's sentence on the board) had as effective consequence to allow pupils to specify the problem to be solved.

Thus, in this sequence, the observed convergence has a double effect: the precision of the problem's formulation, and shared by at least the 7 pupils who speak in this short exchange.

Script 2. A moment of convergence (experienced teacher).

382 – Student: *When we grow up, the spine grows too. So when the rabbit grows up, its spine will get longer. That's why we drew a spine.*
383 – Teacher: *On your drawing did you explain how the spine grows?*
384 – Student: *In fact when you eat, the spine grows along with it because there is a kind of food, let's say it like that, which makes it grow*
385 – Teacher: *How does the food make it grow?*

In 382, a pupil focuses on the growth of the body to explain why he drew the spine: when the spine grows, the body grows too.

In 383, the teacher focuses the theme (382) on the problem of growth.

In 384, the student initiates the construction of the concept by setting temporary relationships between the food entering the body and its growth. Such a link allows the idea of distribution to be built (how the "*kind of food*" makes it grow) in connection with the ideas of transformation and sorting out envisaged earlier ("a sort of"), because it is not what you eat but something a little different that makes its bones grow.

In 385, the teacher resumes the questioning about the problem of growth (after 383). We explain this intervention to be a sort of recovery-change from "*food*" to "*kind of food*".

We consider that her interventions 383-384 act as inductors for the position of the problem (Schneeberger & Lhoste, 2010; Lhoste, Peterfalvi & Schneeberger, 2010). Her questions initiate an explanation from pupils and arise from a solution proposed by pupils to a condition of the problem (it is necessary to make the bones grow).

Furthermore, we analyze this extract from the point of view of the construction of a discursive community applied to science education (Bernié, 2002).

In 382, the pupil's speech is relatively general ("*we*") instead of using the specific example studied here. The pupil tries to give an explanation whereas his formulation still shows a tension between an explanation ("*therefore*", "*that's why*") and a plain narrative ("*when*" ... "*when*").

In 383, the teacher takes up the intervention 382 of the pupil and focuses on the explanatory dimension of the task: "*Did you explain how?"*.

In 384, the pupil goes on to trying to explain although the explanatory dimension is still a logical chronology.

5.2 Examples of divergence

5.2.1 The development of each pupil (experienced teacher)

Script 3.

22 – Doriane: *How does the rabbit grow?*
23 – Julie: *I do not know*.
24 – Marouan: *Well it's written here*.
25 –Teacher: *You're right Doriane. I could have asked the question too. He has explained the transit of the carrot but he doesn't really explain how the rabbit develops. Any questions?*

In 25, after having highlighted the interest of the answer to the pupil's question which pointed out a problem with the development of the rabbit, the experienced teacher quickly opened the discussion to other pupils ("any questions?"). Although there was an opportunity to focus the pupils' attention on a relevant issue to help them get into a scientific reasoning (e.g. by shifting to writing on the board, as in the previous example), the teacher gave the floor to the class.

We interpret that episode as being divergent; this type of intervention is very common with the experienced teacher. It seems that this is a professional gesture of educational nature which expresses the desire to allow the greatest number of pupils to express themselves and to prize all pupils, but the pupils ended up by not understanding the real sense of the scientific problem. Thus, there is a discrepancy between the pedagogical concerns and maintaining the process of acculturation.

5.2.2 The logic of "labeling" (experienced teacher)

Script 4.

42 – Teacher: *They described all the transit of the carrot inside the body, it goes out, this means that it came in. Any questions?*
43 – Julie : *Marla*
44 – Marla: *Why did you speak of cells when you do not know what they are?*
45 – Julie: *Well actually …*
46 – Teacher: *Where does it come from, that word, where did you find it?*
47 – Julie: *Actually Andrea wrote it.*
48 – Teacher: *Andrea you should know it because you must have heard it somewhere. Yes*
49 – Anthon: *Cells are in the brain.*
50 – Pupil: *And in the blood too.*
51 – Anthon: *Also in the blood with red blood cells*.
52 – Teacher: *Why do the girls have this word in mind? Marouan.*
53 – Marouan: *Because of Gulli*, there is a cartoon that talks about that.*
54 – Teacher: *Is it true that this word comes from Gulli*?*
55 – Pupil: *Yeah, it was "once upon a time in our body.*
56 – Teacher: *Ok, good. Other questions?*

*a TV Channel

We interpret the different interventions of the teacher highlighted in grey as times of divergence. In fact he gets to a professional routine (defining all the words used by pupils) even if the pupils' requests lead them away from the scientific issue at stake in the session. We can notice that this divergence belongs to a different category from the first one. While in the first example the divergence came from a conflict between the purpose of encouraging the problem building and the wish to involve everybody in the debate, here the divergence springs from two antagonistic conceptions of science itself: one in which problem building is considered as crucial, the other one in which the words and their meaning must be clarified before. So the discrepancy is more epistemological.

6. Results

In these examples we can see that some actions of the teacher, regularly found in school teaching (such as writing a question on the board), have some general aim so as to involve all the pupils of the class in the activity in progress, whereas other actions focus specifically on the problem's formulation and building. Sometimes, these two categories of actions can support each other, while some other times, they can be antagonistic

We identified times of divergence and convergence with both the novice teacher and the experienced teacher. However, the moments of convergence are more common with the inexperienced teacher than with the experienced teacher. Times of divergence are (three times) more frequent with the experienced teacher. In the class of the experienced teacher, all the moments of convergence happen at the end of the debate (371-433).

From our analyses, we can distinguish which actions promote the construction of a scientific problem in the classroom and what those which delay it. However even if one of the teachers (the inexperienced one) was more focused on the problem building than her colleague, her task is not free of tensions and requires choices which sometimes makes her deviate from ongoing important reasonings.

These kinds of tensions must be taken account to better understand how a teacher adjust his actions while allowing the students to appropriate scientific ways of knowing.

7. Discussion

Our initial analysis, which is limited to a single case, even if two different ways of teaching have been studied, allows us to identify the fact that some professional teachers' common actions could be in either convergence or divergence with the process acculturation to science In the case of the experienced teacher, the professional acts that correspond to regular routine, even if connected with « socio-constructivist » practices, such as group learning and debates, are often in divergence with the construction of the concept studied (Bautier & Rayou, 2009). In the case of the inexperienced teacher, moments of convergence are more frequent.

We make the following hypothesis to interpret the difference between the two teachers: the task of preparing the session in connection with the requirements of her master's degree assignment, compelled the young teacher to identify the scientific problems to build accurately when studying this topic (animal nutrition), to take into account the articulations between them and to anticipate the obstacles to be overcome. The construction of the situation by the inexperienced teacher in connection with the training analysis also seems a favorable element.

The professional acts of the teachers could explain the divergence with the scientific acculturation process of pupils.

The observed difference may also be connected with the fact that the experienced teacher has the whole responsibility of his class, and therefore, has to take into account many more constraints than those directly connected with this specific problem. The inexperienced teacher is in charge of that sequence only, she doesn't know all the pupils very well, she is in a much more protected situation. Because of this, she doesn't have to cope with the professional conflicts the experienced one does. This is a very important fact to take into account, because it can directly influence the success or the failure of this kind of teaching.

Our results are only preliminary and need further investigation: interviews to support our initial analysis and, above all, other types of comparison. We suggest that teacher training does not consist in simply giving teachers a bank of problem situations they just have to implement, or in teaching them directories of professional actions, but to give them a consistent didactic culture so that their action is geared to the acculturation process in science.

These are suggestions, not requirements or recipes.

Acknowledgements

We'd like to thank Jean-Louis Vern, teacher of English, for his helpful translation of the French version.

REFERENCES

Bachelard, G. (1938). *La formation de l'esprit scientifique*. Paris: Vrin.

Bautier, & Rayou, P. (2009). *Inégalités d'apprentissage: Programmes, pratiques et malentendus scolaires.* Paris: Presses universitaires de France.

Bernié, J.-P. (2002). L'approche des pratiques langagières scolaires à travers la notion de "communauté discursive": Un apport à la didactique comparée? *Revue Française De Pédagogie*, *141*, 77-88.

Brossard, M. (2004). *Vygotski: Lectures et perspectives de recherches en éducation.* Paris: Presses universitaires du septentrion.

Canguilhem, G. (1965). *La connaissance de la vie*. Paris: Vrin.

Clément, P. (1991). Sur la persistance d'une conception: La tuyauterie continue digestion - excrétion. *Aster*, *13*, 133-155.

Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher*, *23*(7), 5-12.

Laisney, M. (2011). *Le pilotage de l'activité de problématisation des élèves lors d'un débat scientifique en classe du point de vue des inducteurs de problématisation.* Mémoire de M2. Saint-Lô : Université de Caen-Basse-Normandie, IUFM.

Lhoste, Y. (2008). *Problématisation, activités langagières et apprentissage dans les sciences de la vie*. Thèse de doctorat en sciences de l'éducation non publiée, université de Nantes, Nantes.

Lhoste, Y., & Peterfalvi, B. (2009). Problématisation et perspective curriculaire en SVT : L'exemple du concept de nutrition. *Aster*, *49*, 79-108.

Lhoste, Y., Peterfalvi, B., & Schneeberger, P. (2010). Poser et construire un problème en classe de SVT. Quels repères pour l'enseignant? *Congrès international AREF 2010*, Genève, 13 - 16 septembre 2010. Disponible sur Internet: https://plone2.unige.ch/aref2010/symposiums-courts/coordinateurs-en-f/le-modele-des-inducteurs-de-problematisation (consulté le 27 avril 2011).

Popper, K. R. (1972). *Objective knowledge: An evolutionary approach.* Oxford [Eng.]: Clarendon Press; New-York: Oxford University Press.

Schneeberger, P., & Lhoste, Y. (2010). Le rôle de l'enseignant dans l'évolution du questionnement des élèves en classe de *sciences de la vie et de la Terre* (SVT). In M. Fabre, A. Dias de Carvalho & Y. Lhoste (éd.). *Expérience et problématisation en éducation. Aspects philosophiques, sociologiques et didactiques* (pp. 183-203). Porto: Ed. Afrontamento.

Schneeberger, P., & Vérin, A. (2009). *Développer des pratiques d'écrit et d'oral en sciences*. Lyon: INRP.

Vygotsky, A. (1986). *Thought and language.* Cambridge, Mass: MIT Press.