CONVERSION OF REGISTERS AT PRIMARY SCHOOL: THE LEARNER'S OR THE TEACHER'S RESPONSIBILITY ?

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Abstract: *Our communication fits into a wider study dealing with the activity of the learner and of the teacher during the solving of numeric problems at primary school. This article focuses on the first stage of our research, during which we examined the place given explicitly by the teacher to the conversion of representation registers, within the framework of solving numeric problems at primary school. It describes and analyses a practice of education which allows us to examine on the one hand how a teacher delivers, this conversion of registers to the learner in an explicit way and then how learners take into account this devolution in order to practice useful conversions during the problem-solving activity.*

1- INTRODUCTION

Having noticed in the first part of our research [Priolet, 2000] that on the one hand mathematical textbooks effectively contained problem solving wordings having a non exclusively discursive presentation but that on the other hand certain teachers tried to take on this role of knowledge transmission either by totally ignoring the textbook, or by curtailing the wordings and by giving them a completely discursive shape, we questioned the role which the teacher is effectively going to assign to the various registers of representations, according to R. Duval [Duval, 1995]. Having situated the theoretical frame to which we refer, we will examine and analyse a problem-solving situation during which the teacher leads learners to use the conversion of registers to solve a problem.

2- THEORETICAL FRAMEWORK AND RESEARCH QUESTIONS

R. Duval regrets the weak consideration, in education, of the diversity of semiotic registers that nevertheless characterise mathematical activity. He establishes a classification of the various registers [Duval, 1999] susceptible to being used in mathematical stages and clarifies that the originality of mathematical activity is in the simultaneous use of at least two registers of representation at the same time, or in the possibility of changing the register of representation at any time. How is the pupil going to proceed if he is confronted from the beginning with a single register only? Regarding types of alterations of the semiotic representations, R. Duval distinguishes procedures (alterations which are made by means of the same register) and conversions (alterations which consist of changing register whilst keeping the same denoted objects) [Duval, 2000]. When we calculate in the same system of writing representation of numbers or when we resolve an equation or a system of equations, we are speaking about *procedures*. When we pass from algebraic writing to an equation in its graphic representation or even from a natural language instruction to a relation in its literal writing, we are speaking about *conversions*.

R. Duval underlined the importance of conversion in cognitive activity and regrets that numerous studies in mathematics didactics are based around the search for isomorphism, a strategy nevertheless already denounced in the 30s by L.S. Vygotski [Vygotski, 1977]. However, is this activity of conversion, to which R. Duval assigns an essential role in problem solving, present in the teaching of the resolution of problems? And if it is, what are the effects of these practices on the pupils' problem-solving results? These are our main questions.

R. Douady based a part of her studies around "changement de cadres" [Douady, 1986] which she defined as being *a means to obtain various formulations of a problem which without being inevitably completely equivalent, allow a new access to the difficulties met and the application of tools and techniques which were not themselves imperative in the first formulation*. She described and analysed situations focusing at the same time on both the *tool-object dialectic* and *framework games*, the first being creative of sense and the second being a source of imbalance, to analyse the connections between the teaching and the learning of mathematical knowledge. The framework changes [R. Douady speaks about algebraic, arithmetical and geometrical frameworks, but also about qualitative or algorithmic frameworks] allow the pupil to break with the method "I learn, I apply" to go towards an active practice and a different form of education. These framework changes can be the initiative of the pupil; they will be called "spontaneous", or provoked by another learner or by the teacher. R. Douady noted the gains, for the majority of the pupils concerned by the experiment, of acquisitions by the tool-object dialectic and by framework games, the latter allowing the pupils to progress in problem solving, by freeing a situation or by developing the concepts.

It seems to us that the studies led by R. Douady and those that we wish to engage in are based on the same problematic: Can the passage (which she names *change* and which R. Duval names *conversion*) from a state [*a*] to a state [*b*] of a data set in the same group favour the mathematisation of the situation in order to resolve it more easily?

But we also think that it is necessary to include a social perspective in our research. Therefore, our research begins with observations in classrooms. Just as T. Wood and Turner-Vorbeck have written [Wood, T and Turner-Vorbeck, 2001], "it is essential to look into the classroom situation to see how teaching is contributing to the mathematical meanings that are evolving and to examine how teachers'actions contribute to children's social learning." One aim of our research consists in analysing the different roles that the teacher has to play in the classroom, therefore we refer to researchers such as Paolo Boero [Boero, 1995] and to M. Bartolini Bussi and M. A. Mariotti when they analyse the introduction and the place of tools

–technical and psychological tools- when they are introduced intentionally into activity from the outside [Bartolini Bussi, M.G. and Mariotti, M.A., 1999]

3- OUR RESEARCH

Selection: Five primary school teachers participated in this first part of our study. Drawing lots on a random choice basis. One of them was inexperienced (six months' experience), two were very experienced (36 years' experience) and two were experienced (between 8 and 25 years experience).

Procedure and method:

We asked the five teachers – teaching in classes of pupils aged 10 and 11 years – if we could observe a lesson concerning problem solving. They choose the subject. We conducted lesson observations and teacher interviews. We made tapes and we took video films of the five classes. Four teachers didn't ask their pupils to use representations in order to solve the problems and the fifth one (Mr C) asked his pupils to use representations: Mr C introduced the conversion of representations. Therefore, in this paper, we only use the results of the fifth teacher's pupils in order to examine how conversion belongs both to the learners and to the teacher. For more details about the other observations [Priolet, 2001].

Observation and analysis of a situation:

Teacher: Mr C; 21 ten-eleven year old pupils; four classes in the school; situation: a small village in the centre of France. Length of the lesson : 55 min.

Mr C. having read the instructions of the problem below asked his 10 or 11-year-old pupils to solve the problem in two stages:

- First to use drawings, graphs, diagrams, tables, or any other representation of their choice,
- Then, to answer the question.

Problem:

Alan, Maxime and Julie want to make a game for their younger brother Oliver who goes to play school. They decide to cut out coloured stickers so that Oliver can make boats by assembling them. For this purpose, the following rules are set:

- Boats can be white, green, red or black;
- We can choose between sails, an engine or oars;
- There are two sizes of boats: small and large.

The three children think that Oliver will be able to make lots of boats…

They start to think about the *number of different boats* that their brother will be able to make with the stickers.

Help them solve the problem.

For this purpose:

1°) Use a representation of your choice.

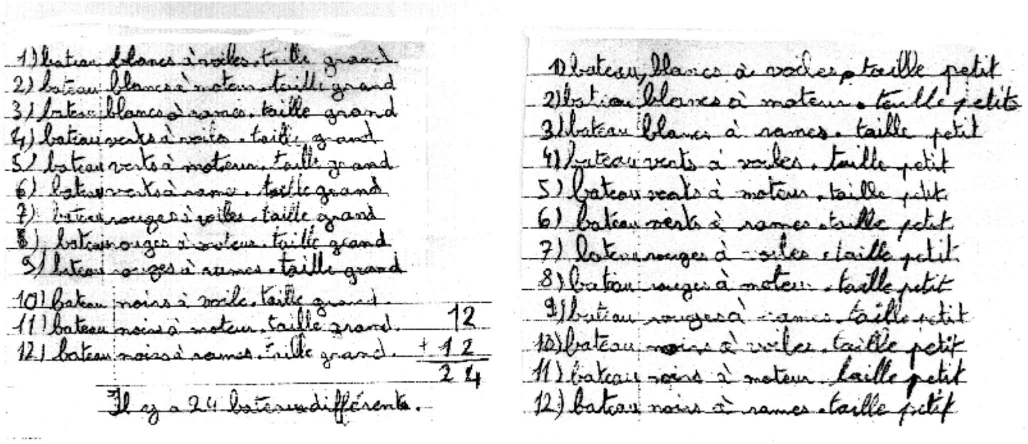
2°) Write down the number of different boats.

The work and the results of the pupils

The pupils worked individually. We were interested in the types of procedure or conversion implemented by the learners. Starting from an exclusively textual statement, did they stay in a discursive form or did they organize their data in the form of diagrams, tables or other representations? Looking at the work and results of the pupils, we could divide the conversion into five groups. I will list them according to the type of procedure or conversion used.

From the textual statement to a textual form

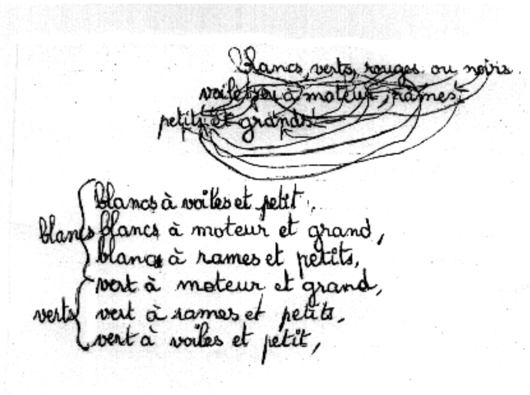
[Pupil x01] This pupil [pupil x01] suggests the following representation:

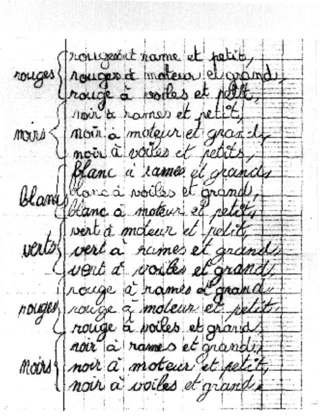

1) bateau blancs à voiles. taille grand
2) bateau blancs à moteur. taille grand
3) bateau blancs à rames. taille grand
4) bateau verts à voile. taille grand
5) bateau verts à moteur. taille grand
6) bateau verts à rame. taille grand
7) bateau rouges à voiles. taille grand
8) bateau rouges à moteur. taille grand
9) bateau rouges à rames. taille grand
10) bateau noirs à voile. taille grand
11) bateau noirs à moteur. taille grand
12) bateau noirs à rames. taille grand.
12 + 12 = 24
Il y a 24 bateaux différents.

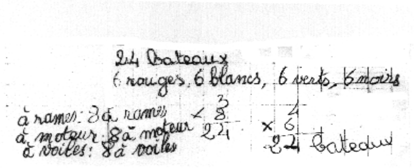
1) bateau blancs à voiles taille petit
2) bateau blancs à moteur taille petit
3) bateau blancs à rames. taille petit
4) bateau verts à voiles. taille petit
5) bateau verts à moteur. taille petit
6) bateau verts à rames taille petit
7) bateau rouges à voiles taille petit
8) bateau rouges à moteur. taille petit
9) bateau rouges à rames taille petit
10) bateau noirs à voiles. taille petit
11) bateau noirs à moteur taille petit
12) bateau noirs à rames taille petit

This pupil [x01] stays in a discursive register. On the other hand, he already operates a sort of classification and we can identify signs that border on an organisation in the form of a tree. This pupil first considered the *size* criterion then varied the other two criteria: *colour* and *propulsion mode*. We observe the procedure and, in spite of a visible textual form we are already in a process of *conversion*.

[Pupil x02]







We find an aid by textual representation in the work above where, after an attempt to use a sagittal diagram, the pupil returned to a textual register, there again very structured and we notice that having first considered the *colour* criterion by associating it to the *propulsion mode* criterion, he then added the *size* criterion:

Attempt 1:	Attempt 2:
white with sails	*white with sails* ***and small***
white with engine	*white with engine* ***and large***
white with oars	*white with oars* ***and small***

In the second attempt only, by taking the results obtained by the two first criteria, he added the unused criterion, the *size* criterion. He therefore advanced further:

Attempt 3:

white with sails ***and large***

white with engine ***and small***

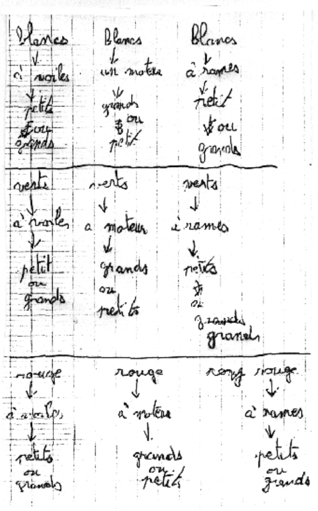
white with oars ***and large***

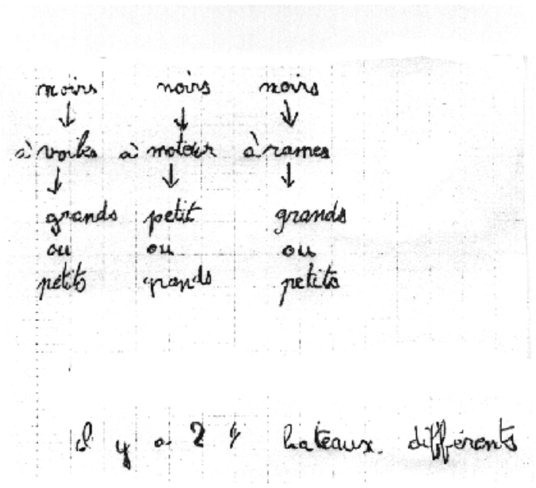
The first attempt of representation in the form of a sagittal diagram certainly influenced the continuation of this pupil's work.

From the textual statement to the diagram

[Pupil x03]

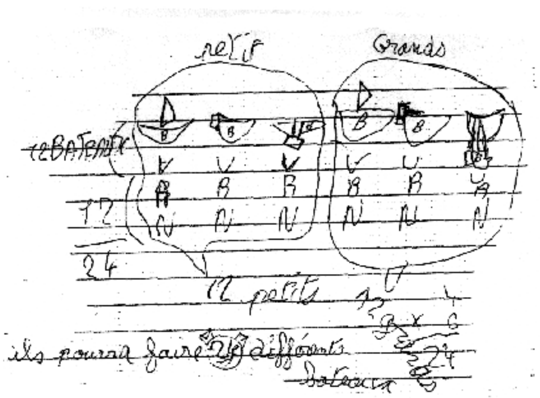
In the following representation, we are very close to the representation in the shape of a *tree*, where it would be sufficient not to repeat the same colour adjective three times. We are indeed in the presence of a conversion, because the pupil x03 went from a register (textual) to another register (non-textual).

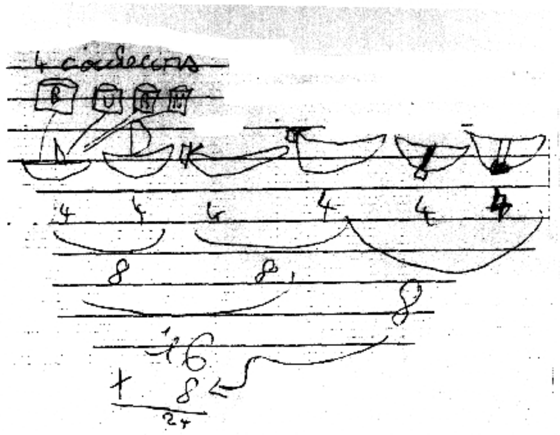




[Pupil x04]

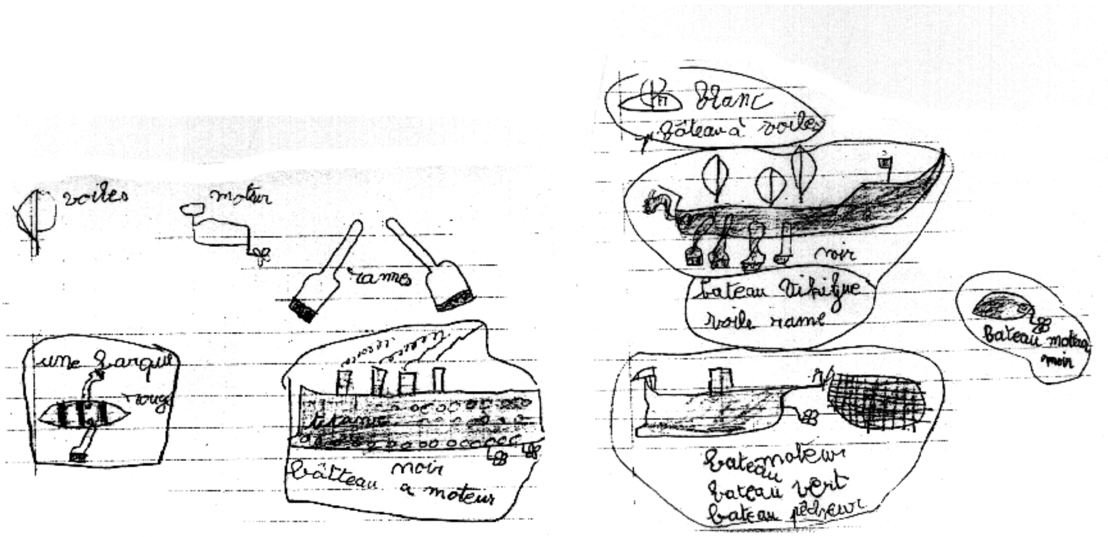
We find the same organisational structure in the following example. Furthermore, this pupil **[Pupil x04]** implemented the same step twice: his first attempt started with the *size* criterion, then he started again by taking this time the *colour* criterion as a starting point.





From the textual statement to an iconic representation

[Pupil x05]



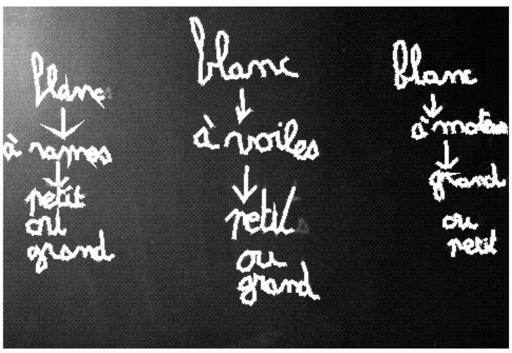
This fifth example **[Pupil x05]** shows the conversion of the textual representation towards an iconic representation, which characterises a drawing. We find ourselves in the presence of a pupil who, starting with textual data, did not look for the number of boats, but the name of boats corresponding to the various categories. And so:

- For a power-driven green boat, he drew a fishermen's boat,
- for a red boat with oars, he drew a boat,
- for a power-driven black boat, he drew the "Titanic".

He systematically avoided the *size* criterion.

The work of the teacher [Mr C]

In the first part of this sequence (see above), the conversion of registers of representations is the learner's responsibility. Then, they are the exchanges of work during successive demonstrations in front of the group/class to present the means used to come to a result ; this helped find the weak points and the key points of every work. Exchanges created by the teacher will allow the intervention of an 11-year-old pupil who will present the conversion in tabular form.



Tree

Table 1

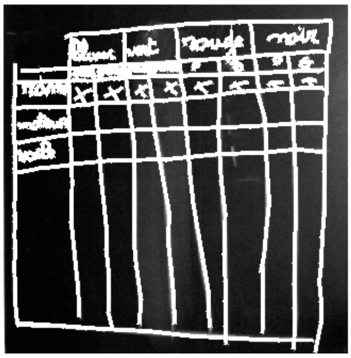


Table 2

These are the exchanges amongst learners that allowed the movement from representations such as the tree (quoted by the pupils, drawn on the blackboard and validated by both the learners and the teacher) to the representation in tabular form. Here the teacher has a real intermediary role: he sets up a situation aimed at improving the exchanges amongst the pupils and he obtains the approval of the group which then works together. “ Implicit in any discussion on teaching is that it is intended *to create learning*” [Pearson, 1989]. The "table" representation evolved exclusively from the exchanges between learners. The above photos show the conversion of registers: we move from "the tree" to a first table, which did not receive the support of the group/class, to a second more functional table. More functional because, without losing sight of the direction of the activity which consisted of counting all the boats, the pupils managed, by using the table, to find the exact number of boats. Indeed, these different tools were introduced by the group of learners, but we underline the role of the teacher who stimulated the interaction between the pupils and “created learning”.

4- CONCLUSION

The above study is aimed at outlining the place effectively reserved for this phase of conversion, which seems to us to be at the core of the problematisation process, within a sequence of problem solving in the elementary school. Once we consider that the conversion of representation is a compulsory and essential passage of problem solving, it is necessary to examine various types of practices. Is it a question of leaving the conversion in its entirety to the learner who should pass from a problem instruction either in natural language, or in tabular or graph form, to another type of representation, without the support of "learning vectors" (teacher, school textbook, software)? Or is it a question of favouring the conversion by giving the pupil outside tools (on paper, or via software)? Or is it a question for the teacher to be responsible for this phase of conversion within the framework of a problem solving educational method?

The observation of various practices will lead us later to devise a typology of situations in comparison to the place given by the teachers to the conversion of registers. The above study placed us in the presence of a teacher who allowed the learners to regulate this conversion:

- on the one hand by giving them clues in the instructions to intervene in the process of problem construction or reconstruction, without doing the conversion for them,
- on the other hand by favouring the exchanges between pupils and between pupils and teacher during the phase of correction.

Can we consider this use of conversion just as a tool of "semiotic mediation" that is introduced intentionally into the activity from the outside [Bartolini Bussi, M.G. and Mariotti, M.A., 1999] offered by somebody else, such as the teacher and the other pupils or can we consider that this construction is more than an external guide and that it will help the learners to activate a process to find the different solutions of the problem?

Our later works will lead us to examine the contributions but also the limits of the various practices met in educational-learning situations which put the conversion of registers in the foreground or in the background.

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