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Implementation in Class of a Theory Stemming from a Research: A Question of Didactical Transposition

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Implementation in Class of a Theory Stemming from a Research: A Question of Didactical Transposition

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Abstract

This article aims to point out some results about the implementation of a theory stemming from a research; we are going to discuss its contributions and limitations. A future primary teacher in his masters year at the University of Geneva decided to try to implement the notion of *sets of tasks* (« jeux de tâches »), developed in our PhD (Del Notaro, 2010). That concept describes the experimenter as an element of what Brousseau (1998) calls the *« milieu*[1] *»* who involves his own knowledge to interact with pupils. First of all, we are going to describe what we mean by the notion of *sets of tasks,* where it comes from, and then give a definition. Then we are going to state the problem by exposing our main idea: the fact that the exploration of the *milieu* by the experimenter will interact with the exploration done by the pupils. This will demonstrate that this interaction is an interaction of knowledge. Our research methodology is also going to be presented. Finally, we are going to expose certain effects of didactical transposition and to analyze the interpretation the student has made. We are going to show how the transposition of a theory in class transforms and makes the knowledge evolve. As a conclusion, we are going to mention that although the exercise was quite successful in some aspects, there should be a discussion about the effects of the transposition, to understand the evolution of the knowledge. It is certainly not easy to define this point, but we are going to propose some elements of reflexion.

Keywords: Teacher education, didactics of mathematics, sets of tasks (*jeux de tâches*), interaction of knowledge, 11-12 year-old pupils, experience.

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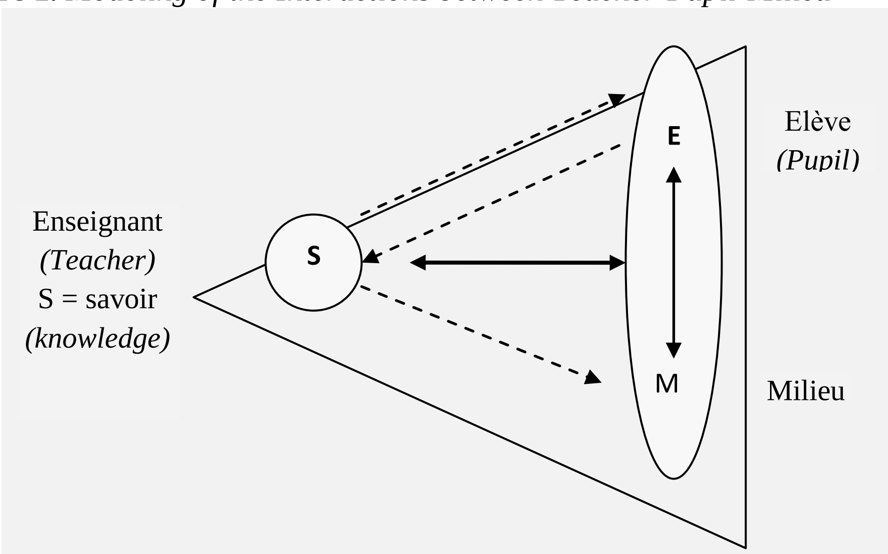
[1]The *milieu* concerns everything which surrounds the pupil's mathematical activity. It can be the mathematical content, the material, the teacher's intervention.

Introduction

Presentation of the Context

Our researches are in the continuity of the *Theory of Didactical Situations in Mathematics* (Brousseau, 1998). After starting with empirical observations of teaching situations in several classrooms and the lesson plan contexts of future teachers, we got interested in the concept of *situation*, and especially in the concept of *fundamental situation* that we have questioned through the notion of *set of tasks* developed in this article. We are going to use the concept of *milieu* to question the relationship between the experimenter and the pupils in a mathematical situation. The *milieu* of the pupil is defined by Brousseau like the *"antagonistic system of the taught system"* (our translation) (1998). Indeed, to learn, a pupil must act against the *milieu*. There is a double interaction: the "pupil ↔ *milieu*" system interacts with the mathematical knowledge of the situation. "The *milieu* is a set or part of set which behaves like a non-finalized system" (our translation) (ibid, 1990). The professor, on the side of knowledge, plays with the system "pupil ↔ *milieu*".

Figure 1. *Modeling of the Interactions between Teacher-Pupil-Milieu*



We have particularly highlighted (Del Notaro, 2010) the causal link between the way pupils build their experience and the investigation of the *milieu* by the experimenter. We have thus developed the idea that the experience is especially built in that kind of interaction, stimulated by a set of tasks.

Development of the Question

Using our sets of tasks, we have tried to understand how a mathematical content appears in the pupil's *milieu* as well as in experimenter's, and how both of them interact. Our hypothesis is that the *milieu*, as well as its exploration by the experimenter, interacts with the exploration done by the pupils themselves.

Why a set of tasks? As a researcher, when we question pupils, it is to understand how they build knowledge. Doing so, we are part of the *milieu*, as our words have an impact on what pupils will do and how they will react. In a current of dynamic scientific thought, we cannot reasonably consider the experimenter as a neutral element, without any influence on the thought of a subject. There is an impact of our own mathematical knowledge on the one of the pupils, and vice versa. We are currently looking at in how the pupil's knowledge is being built within the interaction with the experimenter. Our observations have shown that mathematical knowledge is built in an active process, while leaving a little part of improvisation of both parts: pupils and teachers. In fact, the experimenter "piloting" the situation can put into the *milieu* a new task he had not foreseen in its first analysis. That task is created spontaneously and influenced by the interaction with the pupils; the experimenter can then decide to propose it or not. These unplanned tasks are probably related to the personal exploration of the experimenter, but we have decided not to try to show this fact. The study of didactical *milieu* and situations is therefore in the center of our work.

Origin, Definition and Use of the Set of Tasks

Origin

The set of tasks was a concept first developed by the group DDMES[1] (2003), which brought together teachers and researchers. Their work focused specifically on the field of geometry in primary grades, in special education. In its 2003 text, the Group outlined a very decisive idea for our own research: the idea of an extension of the *milieu*. This notion means exploring and investigating deeply the *milieu* with pupils. The notion of extending (or stretching) contains the idea to explore the limits of the task which is going to grow and extend in a mathematical way. The *milieu* is not a static entity, but a dynamic one. Only a few papers have been written on this topic and we are going to try to contribute to the analysis of this matter. We have included this idea in our research (Del Notaro, 2010) on the numerical field in standard primary classes; we have especially explored the criteria of divisibility of numbers and their connections. To the image of *stretch* or *extension* just described, we have associated certain autonomy in the pupil's questioning. Thus, we have questioned them according to our own representation of the task and sometimes even beside our preliminary analysis. The goal here is not to see if pupils succeed or not, but to understand in an epistemological perspective how their knowledge is built and then fixed. We are trying to identify how they

[1]Didactique des Mathématiques pour l'Enseignement Spécialisé. F. Conne (Université de Genève et de Lausanne), J.-M. Favre (CFPS, Château du Seedorf, Noréaz). C. Cange (Institut Pré-de-Vert, Rolle), L. Del Notaro (École du Mail, Genève), P. Depommier (Collège Arnold Reymond, Pully), D. Jean Richard (CPHV, Lausanne), C. Vendeira (Université de Genève), A. Meyer (ECES, Lausanne), J.-D.Monod (Gymnase cantonal, Nyon), C.-L. Saudan (Fondation de Vernand, Cheseaux-sur-Lausanne), A. Scheibler (enseignement secondaire, Aigle).

link their prior knowledge to the mathematical task assigned and find the elements. As the success of the pupils is not our main priority, we may interrupt a task abruptly to understand a fact or to ask another question or even, introduce counterexamples.

Definition

We define as *set of tasks*, a group of, generally but not necessarily, interdependent equally important tasks. The knowledge of both the experimenter and the pupils will interact with each other in the *milieu*. The challenge is therefore to use the pupil's answers to ask further questions, depending on our own interpretation of the mathematic knowledge we suppose the pupils has used.

First of all, we have defined one or more tasks while leaving the possibility of changing the way of questioning, according to the pupils contributions on the spot. This presupposes a good knowledge of what is needed for the tasks. Therefore, they are determined prior to and during the experimentation. This kind of questioning is not neutral for the researcher; it allows intrusion in the pupil's reasoning. To dissect the *milieu*, it is necessary to be somehow intrusive because you cannot simply observe as a bystander. We believe that to find answers you must somehow provoke them. This double meaning word contains both the idea of encouraging them and challenging them in order to test the strength of the knowledge.

We questioned pupils' mathematical knowledge through their proper experience of the numbers structure. This allowed us to *open* the *milieu* and to explore it by using various experiments. In other words, the researcher and the pupils are proceeding together in the set of tasks, stimulated by the knowledge of both parts. This is typical of what we have called *interaction of knowledge*. In our PHD thesis, we have shown the link between an exploration of the *milieu* by the pupils and the construction of experiences, often missing in education, whose consequence is that the pupils have not many opportunities to construct their mathematical knowledge. We have although highlighted (Del Notaro, 2011) the set of tasks' particularity, and the interactions it causes, as well as the experiences done by the pupils. As well as the knowledge, the experience of the pupils is interacting with the researcher's one; we have tried to establish how this experience is shown in the actions of the pupils.

Methodology of Research for an Exploitation of the Set of Tasks

We proceeded by clinical interviews which can be qualified as *interventionist*, i.e. we are authorized to intervene in what pupils say, in order to understand an answer, or to ask for details (for the most banal interventions), or to put ourselves in the interaction, by introducing, for example, new elements in the *milieu.* This way of carrying out an interview introduces surprises not only to the experimenter but also to the pupil. Thus, we do not feel the effects related to a routine because the surprises are productive and we never really know what will come out of the interaction, even if we propose the same starting task several times. Our tasks are related to the field of numbers in standard primary education. The criteria of divisibility and the relations between the numbers remain our ground of predilection to explore relations in the number suites and the connection figure/number the pupils can establish.

An Application of the Theory to be Questioned

Why a Set of Tasks?

Before using this concept in the context of teacher training, we have to specify that the challenge lies in the fact of avoiding considering the set of tasks as a teaching technique. In spite of that fear, we have decided to supervise a student in Master's Degree to have the opportunity to involve her in this research. After attending our doctoral thesis, this student expressed the desire to work in this context to get her Master's degree in educational sciences, with a concentration in education. It was a very interesting experience that we are going to discuss now. Before proceeding further, it seems important to point out the interest shown by this student before even knowing what the experiment was really going to be. What seemed important to us, in a way, was the fact that only the presentation of the set of tasks had given the desire to a future teacher to test it. We have taken this opportunity to discuss the concept and test its strength and its transfer in teaching. Thévenaz (2010) drew up a list of not hierarchical tasks, as a support for the resolution of the game. She then followed the approach of the pupils, proposing tasks like playing cards and creating new tasks if the proposal of the pupils justified it. It showed that behind this idea, *something* attracts the experts. Let us specify however that our first interest is to understand these phenomena and not to propose a method. The set of tasks supposes an interaction of knowledge between the experimenter and the pupil forcing the experimenter to involve his own knowledge to interact with what the pupil proposes. It is a difficult exercise insofar as the knowledge of the experimenter can fail at some point, because, as one knows it, the mathematical reasoning does not take marked out path. That supposes to be aware and take into account its own knowledge and the one of the pupils, what cannot be done without a personal and thorough exploration of the mathematical *milieu*. It is where the difficulty for a teacher lies, but it is not impossible. The student demonstrated in her master's paper how she had created sets of tasks around the concept of powers and what these games brought to her and to the pupils. She allowed herself to improvise from what the pupils had said or done and she left herself being dragged rather far into the relations that could be established between this knowledge of the powers, the one of the pupils and her own. She showed two things: firstly, although the basic framework was established beforehand by herself, it is the interaction between the teacher and the pupils that created and enriched the full content of the lesson. From a trainer point of view, what seems interesting for the continuation of our work is to note the way in which an object can fill a future teacher with enthusiasm and how, by the means of the *set of tasks*, the latter let herself go into her own exploration. We note that by the use of the set of tasks, the student allowed herself to go out of a typical book exercise like this one: *"This week, I will write a letter to 4 friends. Next week, each of them will write a letter to four others, who will do the same next week, and so on. How many people at the end will receive a letter, the fourth week? And how many people will receive a letter at the end of the tenth week?* For example, while she was working on the powers, she "suddenly" decided to switch for Pascal's Triangle; we could then observe the following interaction of knowledge between her and the pupils: what the pupils were doing made her think about her own knowledge what encouraged her to propose a task on the Pascal's Triangle. We could wonder if the student would have allowed herself this change if she had conducted a lesson in a more usual way. However, we have noticed in her paper a too obvious intention of teaching using the set of tasks as a teaching method and not only as an experiment method, which made us question ourselves on possible slips, which will be discussed in the rest of this article.

Which Effects of the Didactical Transposition?

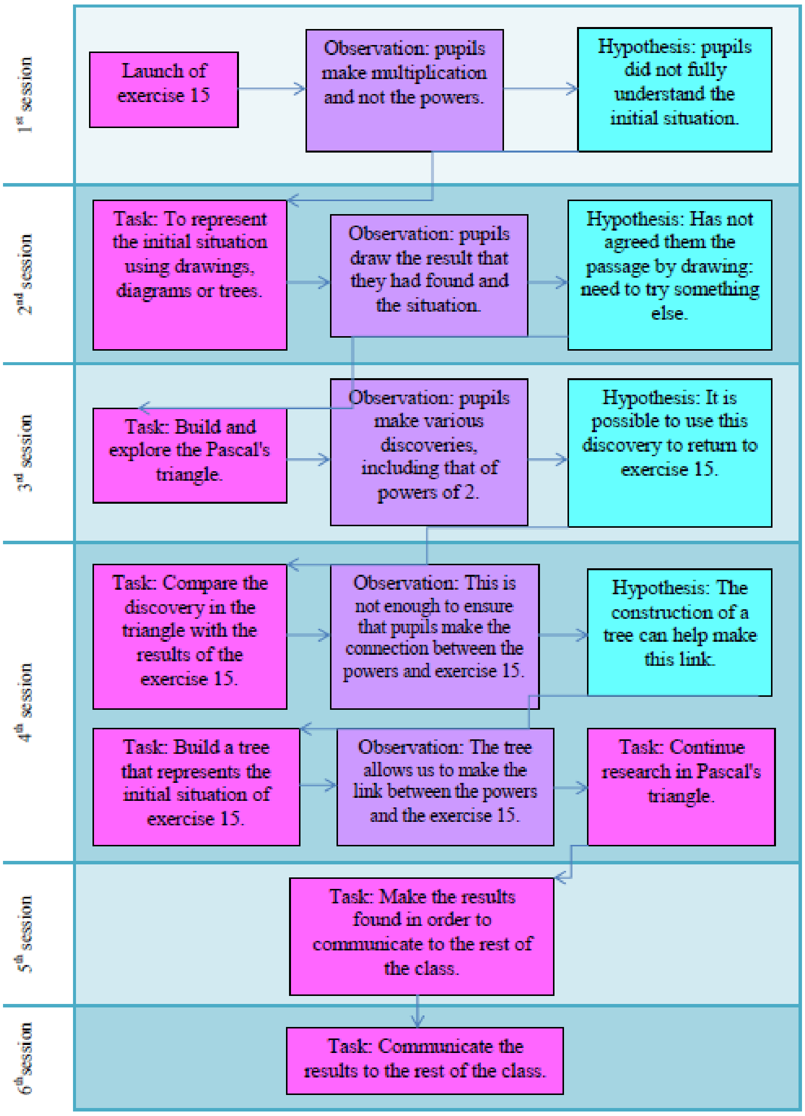
The question of the interpretation of set of tasks notion by the protagonist has to be examined and assessed to understand the transposition process. The application to the contingency of the class causes some slips. It is indeed very difficult to make the difference between teaching and experimenting especially if you are an unexperienced young teacher. The set of tasks is not a technique and shouldn't be understood as a dichotomy right/false. Research must continue to understand under what conditions it could be used in a classroom, and what it really implies for the teacher. What is new is the fact that we don't operate any selection or filtering of the experience. Errors or irregularities may occur and will be considered as a result of the exploration of the pupils. The student, in her set of tasks, attempted to switch from one task to another, according to what pupils were saying, but in order to avoid errors to help her pupils to solve the tasks (even if she wouldn't probably agree with this). Let's take two exchanges about Pascal's Triangle to try to illustrate this (our translation):

- *Compare discoveries in the triangle with the results of the starting task →* ***this is not enough to ensure that pupils make the connection*** *between the exponentiations and the initial task → construction of a tree diagram can help make this link.*

The construction of a tree diagram is not a pupil's idea, but the hypothesis made by the student that it takes over here. She still says:

- *To make a tree diagram that represents the initial task → Tree diagram allows us to make the link between the exponentiations of initial task → Continue research in Pascal's triangle.*

Figure 2. *The Student's set of Tasks (our translation)*



We think that the tasks were all suggested by the student, and that none were really proposed by the pupils. This is a first step toward the set of tasks, yet imperfect, but however positive, if we consider the curiosity of the student and her perseverance in such an uncertain experimental field. Nevertheless, we are pointing out in this work some intentions "to ensure that students learn". This is the kind of slips that we would like to avoid as a researcher, not to transform the set of tasks in a technique. The following extracts, in bold, highlight her own exploration of the *milieu*; she rediscovers some mathematical relations that make her say, at the end of the extract, that she finally got her link. Here is an overview (our translation):

> *"I then asked myself what had taken them to that direction and I finally made the hypothesis that the **pupils had not understood the initial situation**. I then searched **for a way to help them get a representation which corresponded to the situation** we were working on. **When they told me they needed to visualize** what was happening, I decided to use the drawing.*
> ***Then I proposed** to the group of pupils to represent the initial situation using a drawing, a diagram or a tree. (…). After that, I was forced to admit that **my idea of drawing** was not useful for the pupils, and therefore I needed to **find another way to make them understand** the exercise 15. I then read several books and articles, until I found the "Demon of math" (1998). It was then that **I saw the solution I had been looking for**! Indeed, by adding all the numbers of each row, you get powers of 2. Therefore, by taking one line out of two, you obtain the powers of 4: **I finally got my link!** »*

By quickly analyzing these few elements, we realize that, in spite of the efforts made to open the debate about the situation – and this simple fact is remarkable – the teacher's position became more important. The fact that the student said the pupils had not understood the initial situation is a value judgment while the interaction in a set of tasks should only try to help understand what knowledge was required by the situation and used by the pupils. In the set of tasks, what encourages learning is the interaction through knowledge: both parts learn. In the test of the student, learning is promoted by an action of a part on the other: the student "knows"; she finds a way to help the pupils, to make things comprehensible to them, and to lead them to the expected solution. She managed it thanks to the link she had made and not to the one the pupils could have made on their own. Consequently, by establishing the link herself instead of letting the pupils make it, she made a generalization, but the pupils did not. This situation arises as if it contained the discoveries of the pupils. The nuance is subtle because, sometimes very skillfully, one can manage to guide the pupils and to make them formulate the expected discoveries, while maintaining the illusion that they come from them. In our experiments, we did the exact opposite in order to *open* the *milieu*. By not filtering the experience or the links which were revealed spontaneously (that means, we did not intervene), we inexorably caused a destabilization of the *milieu*. What came out of this experiment and was useful to our research, is the fact that we are now well documented and extremely informed on the knowledge the pupils implement when they carry out this kind of exploration and we can thus attest that their experiments are undoubtedly more than simple tests/trials. When a pupil makes a problem his own, and decides to solve it, the interest for the task is guaranteed and the desire to discover more is assured.

Conclusion

Contributions and Limits

Although if the exercise has been rather positive, we have to discuss now the possible slips we had foreseen, when transposing a theory to apply in the classroom. It is certainly not easy to control this point, but we are going to point out some elements. First of all, one of the main contributions is that this way of interacting with the *milieu* of the pupil allows more open interactions; the set of tasks permits a larger development of logic insofar as it manages an experiment, even recommends it. The adjustment of the *milieu* in the sets of tasks allows at the same time the pupils to explore it and also to constitute a proper experience around the concept of powers. This emphasized that prior knowledge have to be adapted in new knowledge. The student, just as the pupils, uses her own knowledge. Let us speak again about the example of the first lesson, where she tells that: *the pupils make multiplications and not powers.* You can obviously quickly explain to the pupils that they are wrong and show them the right way to solve the problem, but in that case, you prevent them to think by their own.

This matter has guided the student's reflection and maintained her enthusiasm to continue the experimentations. Thus, she has been very convinced that if you let the pupils experiment the multiplications by themselves, as long as they need to, you permit them to constitute their own knowledge. That idea has been perfectly understood by the student and has also strengthened her convictions, as well as the fact that she has improved herself this experiment. Another contribution lies in the fact that the set of tasks is an answer to the institutional regulations which require to put the pupils "in situation", but whose practical application remains without any explanation for the teachers. They do not feel helped by the handbooks' theory, which does not take into account the cases where "it does not work" for certain pupils. Therefore it seems much more comfortable to use practical exercises. The set of tasks is a way to put the pupils in situation, making sure that they will learn, although if you cannot always control this fact.

How to Control the Switch toward a Simple Technique?

The challenge is to avoid considering the set of tasks as a new technique. As already told, we have foreseen a possible slip because of the use of the set of tasks as a confirmed technique, which risks reducing it to a simple method: the set of tasks is first of all, an interaction of knowledge which supposes the investment of both, experimenter/teacher and pupil. We have used a theoretical framework (Bloch, 2002) to control our experiments and to characterize the path from an experimental model to the contingency (classroom); we decided not to expose it here, but want just precise that this model enables us to visualize and analyze a teaching phenomenon. Moreover, we can better understand the links between the knowledge of both professor and pupils and their articulation. At rest, this model allowed us to build experimental situations to study and to analyze in the contingency. This modeling helps to guarantee a scientific validity and to avoid the slips of the empiricism, as Bloch (2002) declares (our translation): "The goal of the use of an experimental model *is to make sure that the observation is neither controlled nor limited to the declared choices or not of the professor".* This type of *epistemological vigilance* is missing in the student's paper – how could it be different. Thus, the consequence of her great and positive enthusiasm for her teaching is going with her desire that the pupils succeed in accomplishing the task. She then forgot to leave the pupils think by themselves.

However, we noticed that the student's intention was really to let the pupils search, even if if she does not always succeed. The epistemological posture consists in the idea that pupils learn in the interaction. The experimenter interacts with them in the aim of including and pushing the pupils toward their own knowledge.

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