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ANALYZING CLASS PRACTICES: A PRETEXT FOR STUDYING THE DIFFICULTIES OF THE VERIFICATION OF OHM'S LAW IN FOURTH FORM

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ABSTRACT: *This research describes and analyses real teaching practices of two experienced physics teachers during an ordinary class session of verification of Ohm's law in two Beninese secondary schools, one of them is located in a rural area, the second one in an urban zone. The data we collected are composed of extracts of the curricula of 4th form in physics, activities blank given to the students, the verbatim of the interactions between teacher and students and post session talks with the teachers. Our analysis are based on the Anthropological Theory of learning situations (Chevallard, 1992, 1999, 2005, 2007) and the concept of didactic organization. The results show, on one hand, that teachers have some difficulties to teach Ohm law in respect of the institutional prescriptions. On an other hand, our analysis point out two teachers with divergent epistemological and professional postures.*

Key Words: *Real teaching practice***,** *Ohm's law***,** *difficulties, Anthropological theory of learning situations, professional posture.*

1. STATE OF THE PROBLEM:

Ohm's law is an essential part of the teaching and learning of electricity in Benin from the end of college to the final year or even beyond. Indeed, it brings into play three fundamental concepts of electricity: voltage, intensity of electric current and resistance. Ohm's law is one of the first laws of physics studied in college formulated mathematically and it is based on a homomorphism between the concept of proportionality in the context of mathematics (y = kx) and Ohm's law itself as part of physics (U = RI). In the fourth grade, the programs (GPE 4th, 2007) prescribe the verification of Ohm's law and the graphical determination of the resistance of an ohmic conductor. This requires mathematical modeling involving a functional relationship U = f (I) = R.I of linear type of physical data (measurement of voltage U and intensity I) from an experimental study. As research studies have shown (Pourprix, 1989; Pourprix & Locqueneux, 1989; Malafosse & Dusseau, 2001), the simplicity of the current formulation of Ohm's law hides historical aspects, epistemological controversies and questions that weigh on his teaching and learning today. There is therefore a didactic interest in being interested in the study of Ohm's law.

Previous research (Liegeois & Mullet, 2002; Malafosse, Lerouge & Dusseau, 2000, 2001a, 2001b; Periago & Bohigas, 2005) have highlighted difficulties in conceptualizing Ohm's law among students. These difficulties are essentially linked, on the one hand, to the transition from physical framework and reality to mathematical framework and reality, on the other hand, the relationships between voltage, intensity and resistance for an ohmic conductor. Baldy, Dusseau and Durand-Guerrier (2007) highlighted the difficulties for students to recognize and use these relationships. The various publications have not addressed the difficulties of the implementation of Ohm's law by teachers in the physics class. However, this seems necessary to us insofar as the learning difficulties of pupils cannot be dissociated from the education they receive. This is why, in a programmatic aim, thanks to our master's thesis in didactics of science and technology, we analyzed the teaching of Ohm's law in 4th grade in Benin from the point of view of physical reality which is being built or which can be built in a class of fourth at the college where one studies Ohm's law. This research made it possible, among other things, to highlight a great variability in the praxeology of the verification of Ohm's law with coherence problems likely to make learning this law unintelligible. This is how we sought to describe and analyze the actual practices of physics teachers during Ohm's law verification sessions in ordinary classroom teaching situations.

This is work that seeks to analyze what physics teachers do and how they do it during an Ohm's Law implementation session. This analysis will highlight the difficulties associated with the implementation of Ohm's law for teachers and students. It is based on the identification of constraints both external (linked to the institution, programs, textbooks) and internal relating to an educational situation linked to very specific choices. In this, the analysis is mainly close to the didactic praxeological analysis of the anthropological theory of didactics (TAD) (Chevallard, 1992, 1999, 2005, 2007) which we will use to analyze our observations.

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In what follows, we will first recall some aspects of this theory and then describe the methodological approach used before presenting the results of our research.

2. SOME ASPECTS OF THE ANTHROPOLOGICAL THEORY OF DIDACTICS:

The epistemological positioning of TAD gives knowledge an anthropological character and places all scientific activity in the set of institutional human activities (Chevallard, 1999). Regarding a theme, TAD studies two types of objects: scientific organization, that is to say, scientific reality (mathematical, physical, biological, etc.) which can be built in a class where studies the theme and the didactic organization, the way in which this scientific reality can be constructed, that is to say the way in which the study of the theme can be carried out. Ohm's law is included in Benin's curricula, both middle school, high school and university. To take its place among the teaching / learning objects in the fourth grade, for example, Ohm's law is the subject of a didactic transposition. The implementation of its teaching is prescribed by official programs and instructions. This means that the verification of Ohm's law, like all scientific knowledge, is attached to an institution (at least) which gives it specific meaning and imposes a number of conditions and constraints on it. .

The main tool of the anthropological approach to didactics is the notion of praxeological organization. The term praxeology was introduced by Chevallard (Ibid) as part of the anthropological theory of didactics. In this theory he describes a praxeology as being a quadruplet (type of tasks, technique, technology, theory). Definitions proposed by Chevallard in his writings, this one seems to us quite precise:

> *"In any institution, the activity of people occupying a given position is divided into different types of tasks T, accomplished by means of a certain way of doing, or technique, τ, The couple [T, τ] constitutes, by definition, a know-how. But such know-how cannot live in an isolated state: it calls for a technological-theoretical environment [Θ, Θ], or knowledge (in the restricted sense), formed of a technology Θ, rational "discourse" (logos) supposed to justify and make intelligible the technique (tekhnê), and in turn justified and informed by a theory generally vanishing. The system of these four components, noted [T / τ / Θ / Θ], then constitutes a praxeological or praxeological organization, a name which has the merit of recalling the bifid structure of such an organization, with its practical-technical part [T / τ] (know-how), on the order of praxis, and its technological-theoretical part [Θ / Θ] (knowledge), on the order of logos*" (Chevallard, 1999)

Thus all human activity, social practice and scientific activity in particular, can be analyzed or modeled in complexes according to four components: (type of) tasks, techniques, technology and theory and according to Chevallard (2007) a praxeology is the more or less successful, adequate, relevant union of these four elements. Either to accomplish a certain type of task T and to study a question of type τT. In response to such a question, it will be necessary to set up a scientific organization OS = [T / τ / Θ / Θ]. According to Chevallard (1999): "*Didactic praxeologies or didactic organizations are answers (in the strong sense) to questions like* "*How to study the question q = τT?*" ", Or" *How to study work O?* "- answers which we will note here, generically, ∂q and ∂O, so that we will have for example: ODq = ∂OSq".

A didactic organization, that is to say a didactic praxeology, is therefore the way to set up a scientific organization. From this point of view, and taking into account the specificities relating to the school system such as educational or political choices outside the field of investigation of the didactics of physics, Chevallard (Ibid) clarifies its definition: "*By didactic organization, we a priori will therefore hear all the types of tasks, techniques, technologies, etc., called by concrete study into a concrete institution* ". The main descriptors of a didactic organization are the moments of the study of the scientific organization set up and the topos of the subjects (teacher and students). The moments of study or also called didactic moments are the types of situations necessarily present both qualitatively and quantitatively in the course of a classroom study. These are the types of moments or phases that vary depending on the practice. There are six moments in the study:

- the moment of the (first) meeting with a type of task T or with the scientific organization. This moment tries to answer the question "how to start an activity, a situation, a sequence?" ". This is usually done by meeting a type of task related to the theme, but not always;
- the moment of exploration of T and the emergence of a technique τ. The first meeting leads to the emergence of an embryo of techniques allowing the realization of the proposed tasks;
- the moment of the constitution of the technological-theoretical environment [Θ, Θ]. These are the elements (speeches, definitions, theorems, demonstrations, etc.) which justify, make comprehensible or found the techniques. In general, this phase maintains a relationship between the other moments of the realization of the session;
- the moment of institutionalization: institutionalization, according to Brousseau (1998), is the process in and by which the teacher indicates to students the knowledge or practices that they need to retain as issues of expected learning . According to Chevallard (1999, p. 22), the purpose of institutionalization is to: specify what the mathematical organization "exactly" is, by distinguishing in particular, on the one hand the elements which, having contributed to its construction, will not therefore be integrated therein, and on the other hand the elements which will enter in a definitive way in the mathematical organization concerned - a distinction which the pupils seek to specify when they ask the teacher, with regard to such a result or such a process, whether or not to "know" it.

So therefore relative to a type of task, the class implements techniques underpinned by technologies in order to accomplish it. The teacher, because of his role in the contract which binds him with the students, puts in text what should be retained by the students. This is what Chevallard specifies by writing: the mathematical material (physical such as the verification of Ohm's law) developed is then shaped (by the class, under the direction of the professor) in a synthesis which specifies the different components and "institutionalizes" them almost definitively. (Chevallard, 2005).

- **The moment of work of the technique**

The mathematical or scientific organization having been institutionalized (institutionalized praxeology), the logical continuation of the class activities is to work to reinforce the learning outcomes. This is made possible with formative evaluations and various training. Chevallard (2005) translates this into these words: beyond the synthesis, indeed, the class must then practice mastering the mathematical [physical] contents having undergone this first shaping, and must "make them work": this is the role of the exercises (the word is taken here in its strict sense) and problems ...

- **The time of the assessment**

The knowledge having been put into text and recognized by the class as being the result to be retained, it will be subject to evaluation, whether for training purposes or for summative or certification purposes. In doing so, it is the personal relationships (of students for example) to the knowledge constructed in the classroom that are questioned, taking as standard the institutionalization of the knowledge at stake. The moment of assessment can therefore be interpreted as being an articulation from the moment of institutionalization, that is to say a sub-moment of institutionalization.

- **Topography of subjects**

The Greek word tops means "place". In the school didactic system, during the establishment of a scientific organization (mathematics, SVT, physical ...), there are phases or tasks where the student is brought to operate in didactic autonomy. The whole constitutes by definition its tops. It is the place where the pupil psychologically experiences the feeling of playing in the accomplishment of his tasks, "a role of his own". There is also the teacher's topos. Indeed, in the accomplishment of a task by the student, there is an implicit or explicit subtask which returns to the teacher (for example, to propose to the student a task to be accomplished, to provide the answer to a exercise solved by the students,…). This belongs to the teacher's topos.

3. METHODOLOGY:

We observed two experienced physical science teachers P1 and P2, both state officials holding a certificate of proficiency in secondary school teaching. P1, who has ten years of experience to his credit, was filmed in a fourth year class with his thirty-five pupils and whose age was between thirteen and fifteen in 2015 in a private establishment in the area urban in Cotonou. P2 is used in rural areas in the Savalou commune and has seven years of professional experience in the fourth grades. He was filmed in class with his fourth graders twenty and around fifteen in December 2017.

3.1. Data collection

3.1.1. Audiovisual recordings

During the Ohm's Law Verification implementation sessions, we had two cameras: A well-positioned tripod camera filmed all of the learning sessions. Another, mobile, records in particular what happened within each work group whenever the teacher intervenes in the group. A sound recorder is placed in the level of the different groups (G1, G2, G3 and G4) and records the debates within these groups. We observed one session of the P1 teacher course which lasted approximately two hours and two hours sessions of the P2 course. The recordings have been transcribed.

3.1.2. Various materials

We also collected various materials including:

- extracts from the program and from the program guide on Ohm's law in the fourth grade;
- the student activity sheet designed by the teacher;
- written traces of the students' individual works;
- written traces of the students' group work;
- students' homework copies;
- photographs of the displays on the board of the work of the different groups;
- photographs of the traces written on the table of results obtained by the class group.

3.1.3. Interviews

To complete our analyzes, we conducted a semi-structured interview with the teachers observed. These post-session interviews with the teachers were carried out after setting up the frameworks for their course. They served to:

- spot the gap between what they did in class and what they say they did;
- highlight the reasons that motivated the design of the activity sheet for students;
- bring out what they know about the knowledge to teach relating to Ohm's law;
- bring out their declarative knowledge of Ohm's law;
- bring out what explains some of their didactic choices at a certain point in their realization.

3.2 Data analysis method

We conducted a clinical study of two teachers' practices. The objective is to identify, describe and analyze the different phases of the didactic organization of their actual practice in terms of moments during the implementation of the verification of Ohm's law. The methodology to consist of:

- make an a priori analysis of the tasks assigned by each of the two teachers P1 and P2 to their students. This allowed us to identify the scientific organizations a priori at stake, the possible learnings and the possible knowledge to institutionalize;
- cut out the framework of the teachers' course according to the phases of verification of Ohm's law and describe each phase in terms of praxeology;
- examine the functions of each phase;
- examine how each phase is carried out;
- highlight the tops of the student and the teacher by examining the group work of the students;
- study the relevance and perfectibility of these phases;
- take stock of the achievement of each teacher;
- compare and discuss the teachers' achievements.

Analysis of the interviews will allow us to question the personal report of the teachers. In particular, it will allow us to see if the teacher's personal report conforms to the institutional report to Ohm's law.

4. RESULTS OF THE STUDY:

4.1. Two teachers with different professional postures

Analysis of the session of two teachers shows that it took place according to a ternary structure which begins with an experimental activity of study and research, continued with a collective phase of elaboration and institutionalization of knowledge and ended with a phase of exercises corrected in class. However, the analysis in terms of didactic moments shows that these are nested and can be very intercorrelated with very diverse functions or objectives. The functions of the different phases change, in some cases, in the direction of improving the understanding of imperfectly or difficultly constructed knowledge. In other cases they serve to make up for a missed opportunity to build or institutionalize knowledge. Nevertheless, we have highlighted two teachers who appear as different institutional subjects by their professional postures. One, P2, is characterized by an interactive dynamism which tries to favor a construction by relying on the responses of students to whom it gives enough time to work independently, thus giving the students a "strong" tops. The other, P1, on the contrary, monopolizes the word in long explanations which end in the answers to the questions that he asks himself ("weak" tops of the pupils). One, P2, takes the liberty of deviating from the prescriptions of the program he is contesting, while the other, P1, works to strictly comply with the prescriptions, even if it means ignoring any logic of constructing knowledge with the students.

4.2. Difficulties in implementing Ohm's law verification in the classroom

Our analyzes highlighted the difficulties of the teachers observed in implementing Ohm's law in the classroom at various levels:

- at the level of the construction of a technique for verifying Ohm's law by numerical research of a regularity between voltages and intensities measured for an ohmic conductor in order to highlight a relationship of proportionality between these electrical quantities. This technique, not provided for by the program and therefore on the teacher's initiative, seems difficult to build because it involves not only making correct measurements, making a good approximation of these measurements made, but also and above all succeed in making the link with the concept of proportionality;
- at the level of the construction of an Ohm's law verification technique by graphical research of regularity between voltages and currents measured for an ohmic conductor to highlight the proportionality between these electrical quantities. It is a technique, not prescribed by the institution, which is complex to build by the teacher. Indeed, it is based on the concepts of average straight line to build and linear application which, at this school level and at the beginning of the year or studying Ohm's law, are unknown to the students;
- at the level of reading by induction by the class of a functional relation of linear type U = RI either from a digital exploitation of the measurements of voltages and intensities, or by the exploitation of the straight line, characteristic of the ohmic conductor;
- at the level of the graphical determination of the resistance of an ohmic conductor, prescribed by the program and which requires the implementation of the notions of mean line, of directing coefficient of a linear line not included in the program in fourth grade.

4.3. Differences between the knowledge actually constructed and the knowledge to be taught

Our research has revealed significant differences between what is expected to be taught and what is actually taught at three levels:

- at the level of the statement of Ohm's law, the institutionalizations of the observed teachers highlight the proportionality between voltage and intensity for ohmic conductors while the programs state Ohm's law as the wording of the mathematical relationship between voltage, intensity and resistance;
- at the level of the determination of the resistance by simple measurement with the ohmmeter and by the calculation starting from the mathematical relation of the law of Ohm and not by a graphic method in a will to circumvent the difficulty of implementation;
- at the level of the disciplinary study of the physical sciences, the observed teachers proposed to the pupils a series of activities strongly oriented and directed by him and which takes away from these pupils the investigative approach which would allow them to question themselves on the verification of Ohm's law, to formulate hypotheses and to develop an experimental device to test these hypotheses for finally in order to conclude as to how to verify Ohm's law.

5. CONCLUSION:

In this research, we did an exploratory study of Ohm’s law teaching practices in the fourth grade. It allowed us to highlight deep difficulties in the implementation of this content of knowledge. We have also identified a reluctance (or resistance?) To respect the institutional prescriptions which, moreover, seem to present transparency and problems of coherence both internally and in relation to mathematical didactic programming at the level of fourth grade. However, in Benin, it is the teachers who design the programs. They are the ones who implement these programs. It is still they who constitute the bodies for monitoring and controlling their implementation. In these conditions of difficulties of comprehension of the law of Ohm by the pupils and difficulties of teaching by the teachers in relation to those highlighted in the prescriptions, it seems to us that there is a didactic interest of explore the disciplinary knowledge of physics teachers about Ohm's law to seek to explain on the one hand, the difficulties of conceptualizing Ohm's law (Malafosse et al., 2000, 2001a, 2001, b; Liegeois and Mullet, 2002), on the other hand, the difficulties of implementing Ohm's law in the fourth grade. Indeed, for us, the teacher's practices are dependent on his epistemology and therefore on his knowledge of the object of knowledge at stake.

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