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Exploring the knowledge of teachers about ohm law from a training perspective

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Abstract

Our study aims to evaluate the physics teachers' knowledge about Ohm's law since they are responsible for implementation in the classroom. The study stresses the need to take into account an analytical structure encompassing declarative, procedural, schematic and strategic knowledge and also to use statistical methods to control the mutual influence of each of its elements. Then we have submitted teachers to a paper-and-pencil assessment on simple non-standard questions but whose resolution requires several knowledge to combine together. The study highlights serious difficulties that teachers face in solving problems sufficiently far from those usually encountered at school. In addition, the results show that the evaluation of declarative and procedural and schematic knowledge does not does not guarantee to highlight their functional and operational character.

Keywords: Disciplinary knowledge of teachers**,** ohm's law**,** conceptual difficulties

1. Introduction

Previous research by Malafosse, Lerouge, & Dusseau focused on the difficulties of acquisition and conceptualization of Ohm's law by students in 2000 and 2001. These studies have highlighted difficulties related to the change of space of reality, framework of rationality and register between mathematics and physics. Liégeois and Mullet (2002) [4] studied the way in which students in the end of middle school and the beginning of high school are able to conceptualize the notion of resistance with regard to its relationships with the concepts of voltage and current intensity. The results tended to show that for the majority of students resistance is a direct function of two concepts (voltage and intensity) as might be the concept of power. Other studies (Periago and Bohigas, 2005) [9] have looked at student's conceptions of industrial and chemical engineering about electrical voltage, amperage, and Ohm's law. Far from providing meaningful information on students' conceptions of the relationship between tension and intensity, the research has been very useful in designing and writing courses based on the constructivist approach to the teaching and learning process. This research has the merit of highlighting certain difficulties in conceptualizing the study of Ohm's law among pupils and students. In a recent study (Dognon, Magbondé, Oké & Attikleme, 2019), we analyzed the teaching of Ohm's law in the 4th grade in Benin in the context of ordinary didactic situations. This study made it possible to characterize the physical reality that can be built during these sessions by analyzing the didactic organization of an effective practice of physical science teachers. The results highlight deep difficulties in the implementation of this content of knowledge. This study 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 the didactic mathematical programming at the level of fourth grade. In Benin, it is the teachers who design and implement the study programs. It is among them that the bodies responsible for monitoring and controlling their implementation are constituted.

In this study, we report on the exploration of the personal uses of teachers in situations unusually encountered in school context relating to Ohm's law by asking the following question: What are the knowledge of physics teachers about Ohm's law? How do teachers mobilize the knowledge necessary to solve problems on Ohm's law? These questions are of educational interest. Indeed, for us, the practices of a teacher responsible for making students acquire an object of knowledge are dependent on his epistemology and therefore on his knowledge of the object of knowledge involved.

2. Theoretical References

2.1. Knowledge of an individual and solving scientific problems

According to Herl, O'neil, Chung, Bianchi, Wang, Mayer, … Tu (1999), the teaching-learning processes in science and technology mobilize the cognitive (knowledge), metacognitive and motivational dimensions. Putting emotion and motivation aside Anderson (1982) [1] develops an approach which considers that student learning takes place in three stages. Each of these stages involves a type of knowledge: In the first stage, the learner mobilizes factual (declarative) knowledge to assert a performance requiring a very large work memory load because the declarative data relating to the competence must be repeated for an approximate and rough acquisition of the final skill to be acquired. The second stage is characterized by the conversion of factual knowledge into so-called reasoning knowledge. The culmination of this conversion phase is the abandonment of verbal mediation in favor of a set of production of "if… then" type statements which act on facts stored in the declarative type database. The third stage brings into play regulatory knowledge which implies selectivity in the adjustment and the search for alternative solutions to a relatively complex generalization problem.

2.2. Assessment of scientific knowledge

To evaluate the work of an individual on a given scientific field, Solaz-Portolés and López (2003); Ruiz-Primo and Shavelson (1996) [10]; Shavelson (1974) proposed to break down his knowledge into four complementary types when he solves a problem: declarative knowledge, procedural knowledge, schematic knowledge and strategic knowledge. Shavelson, Ruiz-Primo, and Wiley (2005) [11] present a conceptual framework for characterizing each of these types of knowledge.

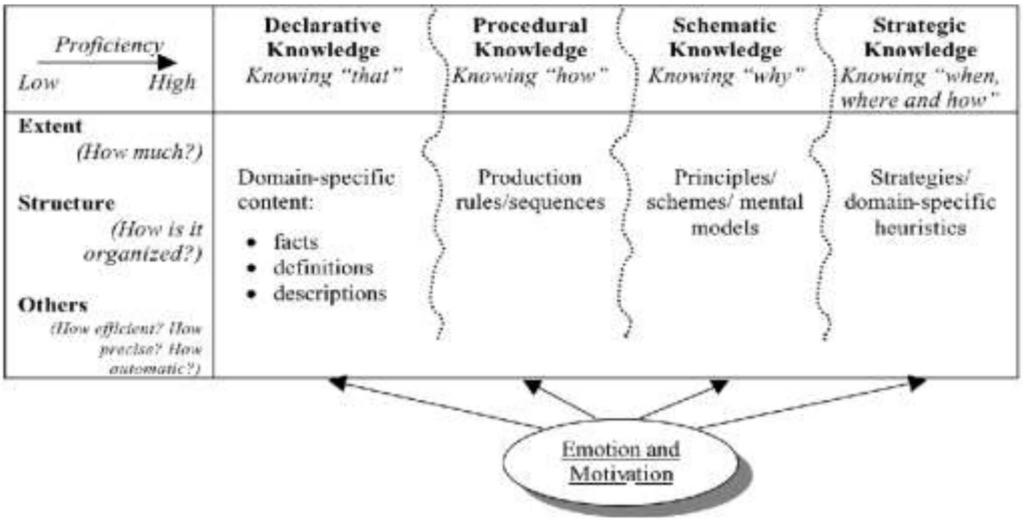

Fig 1: Conceptual framework for characterizing the objectives of scientific work and student success (Shavelson *et al*, 2005 [11], pp. 415)

- The declarative knowledge that Solaz-Portolés and López (2003) designate by "knowing that", (that is to say knowing what) represents all the knowledge that an individual can declare by calling upon his memory. They relate to facts, definitions and descriptions. They group together what Anderson (1982) [1] designates by factual knowledge. Declarative knowledge in the context of the application of Ohm's law can be, among other things, the statement of Ohm's law, the definition of a resistance, the unity of a resistance, the pace the characteristic of an ohmic conductor, the equation translating Ohm's law or the usefulness of such a law.
- Procedural knowledge designates the calculation procedures relating to a specific area. They are what Solaz-Portolés and López (2003) designate by "knowing how" and that Anderson (1982) [1] groups under the name "reasoning knowledge". For example, with respect to Ohm’s law, they can be the procedures for determining (graphically or by calculation) the voltage, current or resistance for an ohmic conductor.
- Schematic knowledge constitutes for Solaz-Portolés and López (2003), the "knowing why", that is to say, "knowing why". They bring together knowledge of general principles and diagrams, limits and reasons for applying laws in a specific area. Specifically to Ohm's law, schematic knowledge can relate to the interpretation of electrical circuit diagrams involving an ohmic conductor, taking into account the limit of use of an ohmic conductor taking into account its nominal power or the interpretation of a characteristic graph of an Ohmic conductor.
- Strategic knowledge, meanwhile, includes that which uses the use of declarative, procedural and schematic knowledge to solve complex problems. Strategic knowledge is equivalent to regulatory knowledge in the approach of Anderson (1982) [1].

Canu (2014) [2] makes a comparison of this division of knowledge with the terminology of Theory of Conceptual Fields (Vergnaud, Halbwachs, & Rouchier, 1978) [13] which models the behavior of students in situation (action). He then proposes to consider declarative and procedural knowledge, on the one hand, as being the predicative form of knowledge and, on the other hand, schematic and strategic knowledge as its operational form.

Solaz-Portolés and López (2008) [12] go further by distinguishing, in addition to declarative, procedural, schematic and strategic knowledge, situational knowledge and metacognitive knowledge that an individual mobilizes to solve a scientific problem.

3. Methodology

3.1. The presentation of the questionnaire

The questionnaire that we proposed to teachers considered to be very experienced is made up of four parts: The first (which we designate by “strategic” questionnaire, is intended to explore the strategic knowledge of these teachers about the law of Ohm, the second part, which we call “schematic” questionnaire explores their schematic knowledge, the third, which we designate by “procedural” questionnaire, aims to assess the procedural knowledge of teachers while the fourth, declarative questionnaire, is intended to explore the declarative knowledge of teachers. We will present each of these parts by highlighting the responses we expect from the teachers in our panel as well as the types of knowledge involved.

3.1.1. The "strategic" questionnaire

In a variant of this questionnaire, we first asked the teachers to indicate on the schematic electrical circuit (Figure 1 in the appendix), justifying the answer, if the L2 lamp will shine more or less if the 'we disconnected the L3 lamp by not putting anything in its place knowing that all the lamps are identical.

Before disconnecting L3, the application of Ohm's law makes it possible to show that the intensity of the current flowing through the lamp L1 is: I_ (L_1) = E / ((r + R + 3/2 R_L)) and that the intensity of the current which crossed the lamp L2 and the lamp L3: I_ (L_2) = I_ (L_3) = E / 2 (r + R + 3/2 R_L), by designating r, R and RL respectively the internal resistance of the battery, the resistance of the ohmic conductor present in the circuit and the resistance of the filaments of each lamp. Indeed, L1 being in the main circuit the intensity of the current which crosses it is divided equally between L2 and L3.

After L3 is disconnected from the circuit, the two other lamps are now in series with the ohmic conductor and the battery. The two lamps are therefore crossed by the same intensity of the electric current 〖I ^ '〗 _ (L_1) = 〖I ^'〗 _ (L_2) = E / ((r + R + 2R_L)). Or 2 (r + R + 3 / 2RL) = 2r + 2R + 3RL = (r + R + 2RL) + r + R + RL> r + R + 2RL. Therefore the current which now flows through the lamp L2 is more intense than that which flowed through it before the lamp L3 was disconnected (〖I ^'〗 _ (L_2)> I_ (L_2)) and therefore the power consumed by L2 (P = R. 〖I_ (L_2) 〗 ^ 2) before disconnecting L3 is less than that which it consumes after L3 has lifted the circuit (P ^ '= R. 〖 〖I'〗 _ (L_2)〗 ^ 2). As a result, L2 will shine more in the new situation.

The resolution of this apparently simple problem requires the reading and interpretation of electrical diagrams, the calculation procedures arising from knowledge of the mathematical expression of Ohm's law, the application of Ohm's law, laws on electrical circuits, simple power calculation and mathematical calculation procedures. It therefore requires the implementation of schematic, procedural and declarative knowledge to be mobilized in a concerted manner.

In a second step, teachers were presented with the plots of the characteristics of three ohmic conductors each mounted in an electrical circuit in series with a lamp (See Figure 2 in the appendix). They are asked to rank the lamps from the least bright to the brightest. By exploiting the voltage-current characteristics, we can compare the slopes GB, GC and GA respectively of the curves (A), (B) and (C). Knowledge of linear lines makes it possible to show that GB is larger than GC which is larger than GA (GB> GC> GA). And so: 1 / R_B> 1 / R_C> 1 / R_A and hence RB <RC <RA, where RA, RB and RC are the respective resistances of the ohmic conductors A, B and C. Under these conditions the I_ (L_2)> I_ (L_3)> I_ (L_1), and therefore R. 〖I_ (L_2)〗 ^ 2> R. 〖I_ (L_3)〗 ^ 2> R. 〖I_ (L_1)〗 ^ 2 with I_ (L_1), I_ (L_2) and I_ (L_3), the respective intensities of current flowing through the lamps L1, L2 and L3. Thus, the electric power consumed by the lamp L2 is greater than that consumed by L3 which is greater than that consumed by L1. As a result the lamp L2 is the brightest and L1 is the least bright.

The resolution of this problem is based on the deployment of a strategy which requires the mobilization of knowledge relating to the exploitation of characteristic curves of an ohmic conductor, the mobilization of the procedures for graphically determining a resistance (schematic knowledge), and the application of Ohm's law and the processes of determining the brightness of a lamp by calculating the power consumed by its filament (procedural knowledge) and of course the knowledge of the mathematical expressions of the law of Ohm (declarative knowledge).

3.1.2. The "schematic" questionnaire

We proposed to the teachers a table of intensity and voltage measurement relating to an ohmic conductor whose maximum power of use was indicated. Teachers are asked to predict the value of the measurement of certain values of voltage or current (See question Q2.1 in the appendix). The resolution of this problem is based on the knowledge and use of the operating limits of an ohmic conductor and therefore the limits of application of Ohm's law for an ohmic conductor. It is necessary to bring out the regularity between voltage and current which crosses the ohmic conductor. We will verify that the U / I ratios is constant and practically equal to 476 Ω by rounding to the unit. Then, taking into account the limit of use of this ohmic conductor, we will show that for a voltage of 12 V the power that the ohmic conductor assumed to be still intact would require: P = U ^ 2 / R = 〖12〗 ^ 2/476, or 302 mW. This value is almost three-quarters greater than the limit of use for the ohmic conductor. Consequently, one could not predict the intensity of the current which would cross the ohmic conductor if it was subjected to a voltage of 12 V. By doing the same reasoning for a current intensity of 0.0157 A, we will find that the power that the ohmic conductor would consume is equal to P '= R. I2 = = 117 mW, a value well below the limit of use of the ohmic conductor. In these conditions Ohm's law is applicable. The corresponding voltage would then be U = R. I = 476 x 0.0157 = 7.5 V.

To overcome this question, it is necessary to know how to use the limit conditions for using an ohmic conductor. These incorporate knowledge based on definitions and statements relating to Ohm's law and certain procedures for applying them.

In another variant of the "schematic" questionnaire, you are asked to indicate, among several curves (see question Q2.3 in the appendix), that relating to an ohmic conductor and that relating to a battery. The proposed graphs describe the variations in the power P consumed by the dipole as a function of the intensity I of the current flowing through it. For any dipole operating in direct current, the power it consumes is written $P = U.I^2$. In the case of an ohmic conductor and according to Ohm's law, U = R.I or $P = R.I^2$. The function P = f (I) is therefore a parabola having the origin of the coordinates O as minimum (curve C). In the case of a battery by applying Ohm's law, the voltage between its terminals is U = E-rI and the power supplied by the battery is $Ppile = EI\text{-}rI^2$. The function P = g (I) is a parabola whose maximum is the point S ($E / 2r$; $E^2 / 4r$) with a concavity turned downwards. It is therefore curve A which relates to a battery in operation.

In both cases, the knowledge to be implemented includes knowledge of the general principles and the reasons for applying Ohm's law, in this case for an ohmic conductor and for a battery. We find there the knowledge of the mathematical expressions of the law of Ohm (for an ohmic conductor and for a battery), the knowledge of certain procedures of application of this law to calculate the power at the terminals of an ohmic conductor and a battery.

3.1.3. The "procedural" questionnaire

We presented to teachers the characteristic voltage intensity of an ohmic conductor (question Q3.1 in the appendix) by asking them to indicate among several values the one which corresponds to the resistance of the ohmic conductor. This is the graphical determination of the resistance of a conductor. The resistance R of the ohmic conductor is obtained by calculating the slope of the straight line obtained. R = a ^ (-1) / a = a ^ (- 2) Ω.

This required recognizing the characteristic of an ohmic conductor and using Ohm's law enforcement procedures.

In a second variant of the questionnaire we asked to choose, justifying the answer, the value of the voltage that exists across an ohmic conductor from among several values knowing the resistance of the ohmic conductor and the electric power it consumes (see question Q3.2 of the appendix). We are waiting for the teacher to apply the formula representing the mathematical relationship of Ohm's law and to extract the tension from it, taking care of the conversion operations: P = U ^ 2 / R or U = √ (P * R)

3.1.4. The "declarative" questionnaire

In this questionnaire we asked six different questions relating to the definitions and formulas relating to the law of Ohm such as the statement of the law of Ohm, the recognition of the formulas translating the law of Ohm, the utility of a such law, the nature of the characteristic of an ohmic conductor, the influence of an ohmic conductor in a circuit. We are waiting for teachers to state Ohm's law by highlighting the proportionality of the voltage across an ohmic conductor and the intensity of the current flowing through it. The relations U = R.I and U = E-ri2 represent respectively the mathematical translation of the law of Ohm respectively for an ohmic conductor and a battery. As for its usefulness, Ohm's law makes it possible to characterize the behavior of a class of dipoles called ohmic conductors, to define the electrical quantity called electrical resistance of an ohmic conductor and its unit. An ohmic conductor makes it possible to modify the intensity of the current in a circuit and the value of its resistance is determining in the brightness of a lamp in the sense that it comes into play in the evaluation of the power consumed by a lamp.

3.2. Data collection

We administered to fifty teachers of physical sciences (chosen for the correction of the Baccalaureate of the 2018 session) a paper-pencil questionnaire to collect from them their procedural, schematic, and declarative knowledge in this order. Teachers are firstly submitted to questions sufficiently distant from those usually encountered in a school context and whose resolution calls for strategic knowledge (strategic type questions), secondly to schematic type questions. Finally, we have submitted them to procedural and declarative questions respectively. This approach is inspired by that of Canu (2014) [2] in that it makes it possible to seek the four types of knowledge in teachers and then study the way in which they mobilize inferior knowledge (declarative and procedural) not announced in advance for solve a schematic or strategic problem. According to Shavelson, Ruiz-Primo, and Wiley (2005) [11], it is difficult to assess an individual's strategic knowledge because it takes time to establish. We are aware of this and we postulate that our subjects had the time to develop this strategic knowledge in the exercise of their profession. In fact, for us, they are among the best and most experienced because the educational institution has judged them able to participate in the correction of the physical science tests of the end-of-school certification exam.

Table 1: Origin and Number of Teachers Questioned

Data collection correction center	Lokossa Center	Center of CEG 1 Calavi	Abomey Center	Center of CEG Nokoué
Number of teachers interviewed	21	10	9	10

3.3. The data analysis method

For each type of question (strategic, schematic, procedural and declarative) we construct a table in which are recorded the answers conforming to that expected (which we denote by the number 1) and those not in conformity with the expected answers (which we denote by number 0) and this for the fifty teachers in the sample. For each type of knowledge, we therefore calculate the percentage of correct answer for each teacher as well as the percentage of correct answer for each variable of each type of knowledge (declarative, procedural, schematic and strategic). To study how teachers mobilize inferior knowledge in the sense of Shavelson *et al*. (2005) [11] to solve complex questions requiring the use of strategic knowledge, we retained an analytical structure encompassing the four types of knowledge.

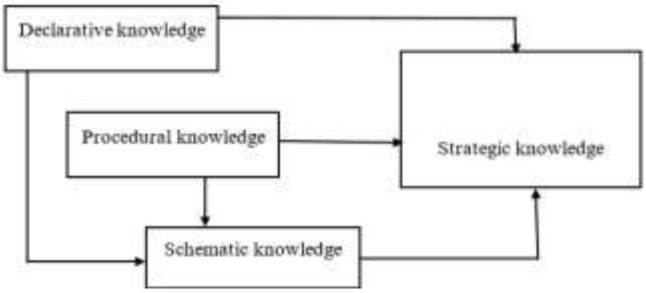

Fig 2: selected analytical structure

From this analytical structure we retain three main categories of variables (percentage of success for declarative knowledge: DCLA, percentage of success for procedural knowledge: PROC and percentage of success for schematic knowledge: SCHE) that we qualify as "explanatory" variables the variable of success for strategic knowledge (STRA) variable category required to solve complex problems. The DCLA, PROC and SCHE variables are therefore our target variables. We seek to assess their influence on the variable STRA.

Our model is therefore: STRA = f (DCLA, PROC, SCHE). We do a multivariate analysis based on statistical processing by the method of multiple linear regression. The principle of linear regression consists in modeling a dependent variable Y quantitative in the form of a linear combination of n quantitative explanatory variables X1, X2,... Xn. By neglecting the hazards, the model is written, for an observation i: yi = a1x1i + a2i +… + anxni + ei where, for an observation i, yi is the observed value for the dependent variable Y, xij the value taken by the variable j and ei is the error of the model. Linear regression is based on two fundamental assumptions: the errors ei follow the same normal law N (0, s) and are independent. For our study the dependent variable Y is the variable STRA and we define three explanatory variables (n = 3), DCLA, PROC and SCHE.

3.3.1. So we get for our model

STRA = a0 + b1DCLA + b2PROC + b3SCHE where a0 is a constant, b is the marginal impact of each variable.

This model offers the advantage of separating the linked effects from the different variables, giving us their net effect; on the other hand, it quantifies the marginal impact, all other things being equal, of each explanatory variable on the explained variable (STRA) (this impact is given by the coefficient b). Finally, each model has its own explanatory power: this model makes it possible to calculate the total percentage of the variance R2 of STRA explained by the set of explanatory variables (DCLA, PROC and SCHE).

In the following tables, we compile all the averages obtained by each teacher relative to each category of knowledge assessed and the summary of the central indicators and dispersion of the study variables.

Table 2: Strategic knowledge explained by procedural and schematic declarative knowledge

Profs	% DCLA	% PROC	% SCHE	% STRA
P1	55,6	75	0,0	50
P2	22,2	25	22,2	25
P3	11,1	50	33,3	0
P4	55,6	50	33,3	50
P5	33,3	100	44,4	50
P6	0,0	0	33,3	50
P7	44,4	0	22,2	50
P8	66,7	25	22,2	25
P9	0,0	0	11,1	0
P10	0,0	0	33,3	25
P11	55,6	75	44,4	75
P12	22,2	0	0,0	75
P13	11,1	0	11,1	0
P14	66,7	75	33,3	25
P15	55,6	25	22,2	50
P16	55,6	75	66,7	75
P17	33,3	25	33,3	50
P18	33,3	0	11,1	0
P19	55,6	100	33,3	75
P20	44,4	100	33,3	0
P21	44,4	75	44,4	25
P22	44,4	0	22,2	50
P23	44,4	100	55,6	25
P24	44,4	75	66,7	25
P25	33,3	75	22,2	25
P26	33,3	75	33,3	75
P27	66,7	75	33,3	50
P28	44,4	75	44,4	25
P29	100,0	75	66,7	25
P30	77,8	75	66,7	25
P31	55,6	75	33,3	50
P32	55,6	100	66,7	50
P33	44,4	75	22,2	50
P34	66,7	75	66,7	50
P35	77,8	100	22,2	25
P36	44,4	75	66,7	25
P37	33,3	50	22,2	25
P38	66,7	100	33,3	75
P39	55,6	50	0,0	50
P40	66,7	100	11,1	50
P41	55,6	100	33,3	50
P42	66,7	50	22,2	0

P43	77,8	75	55,6	25
P44	66,7	25	66,7	75
P45	77,8	100	22,2	25
P46	88,9	100	33,3	25
P47	77,8	75	33,3	50
P48	77,8	75	44,4	25
P49	55,6	25	66,7	25
P50	66,7	50	55,6	50

Table 3: Summary of central indicators and dispersion of study variables

Variable	Observations	Minimum	Maximum	Average	Standard deviation	Median	Scope	Mode
%STRA	50	0,0	75,00	36,44	25,08	50,0	75	STRA 4
%DCLA	50	0	77,8	51,6	16.94	55,56	88.9	DCLA 2
%PROC	50	0	100,0	60	35,35	75,0	75	PROC 1
%SCHE	50	0,00	66,67	33,8	19,89	33,33	66.7	SCHE 5

4. Results

4.1. Teachers' strategic knowledge

Graph 1 shows that only 36.4% of the strategic knowledge assessed was obtained by the teachers. Nearly nine teachers in 10 (88%) have failed to solve a problem that calls for the implementation of a strategy based on the exploitation of the electrical diagram of an electrical circuit, the application of laws of 'electrokinetic (laws of meshes and nodes), the implementation of current intensity calculation procedure, by applying Ohm's law for ohmic conductors and / or by applying law d 'Ohm for batteries, with the aim of determining the power consumed by a lamp in order to judge its brightness (STRA 3).

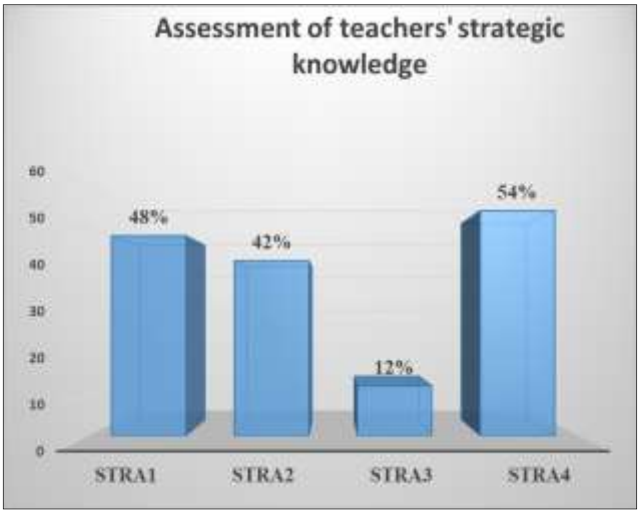

Fig 3: Results of the assessment of teachers' strategic knowledge

However, a little more than half of the teachers (54%) succeeded in solving a problem requiring the mobilization of strategic knowledge (STRA 4) consisting in adequately exploiting the voltage - current characteristics of several ohmic conductors in order to determine the resistances of these then to use the influence of an ohmic conductor in an electrical circuit to compare the intensities of the current flowing in each of the circuits in which the ohmic conductors are mounted and finally conclude with regard to the brightness of the lamps mounted in series with each of the ohmic conductors. Teachers find it difficult to solve problems far enough from those usually encountered in school. Indeed, for problems requiring the implementation of strategic knowledge, teachers struggle to find the right answers expected.

4.2. Schematic knowledge of teachers

Of the seven types of schematic knowledge that we assessed, there is only one that teachers seem to have (see Figure 2). According to the questionnaire we provided them, on average 33.8% of the schematic knowledge was passed by the teachers.

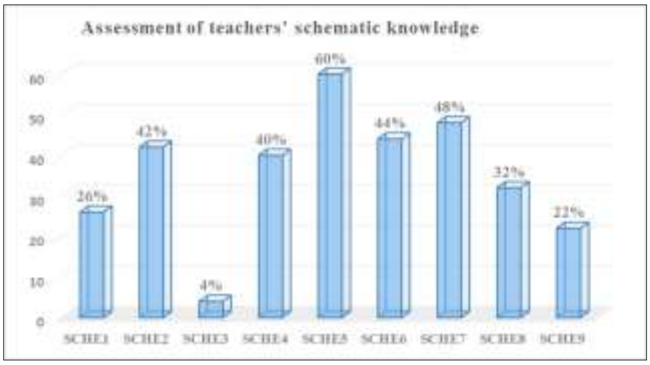

Fig 4: Results of the teachers' schematic knowledge assessment

They seem to have difficulties in the interpretation of electrical circuit diagrams involving an ohmic conductor, in taking into account the limit of use of an ohmic conductor taking into account its nominal power, still in the interpretation of a characteristic graph of an Ohmic conductor or of the influence of this in an electrical circuit.

4.3. Teachers' procedural knowledge

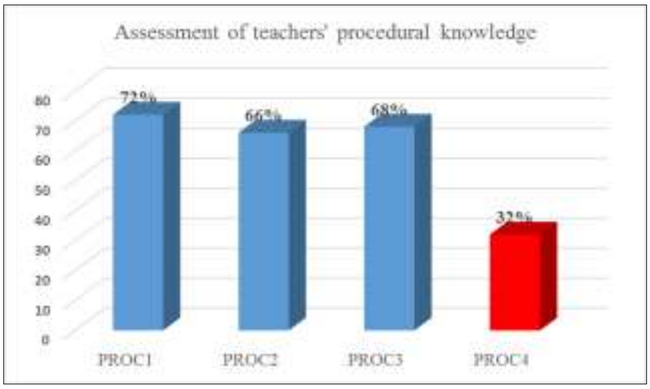

Fig 5: Results of the evaluation of procedural knowledge

The different types of procedural knowledge assessed are passed by the teachers with an average of 60%. The majority of teachers (72%, 66% and 68%) know how to determine graphically and by calculation the voltage across an ohmic conductor and the intensity of the current flowing through it by applying Ohm’s law. However, only a third of teachers (32%) know how to implement the procedure for determining the electrical quantity that influences the brightness of a lamp (PROC4).

4.4. The declarative knowledge of teachers

The result obtained shows a very contrasting picture of the declarative knowledge of teachers. Half (51.6%) of the knowledge at the lowest level of an individual's knowledge (Shavelson *et al*. 2005 [11], pp.415). Barely half of the teachers (54%) were able to correctly state Ohm’s Law (DCLA1).

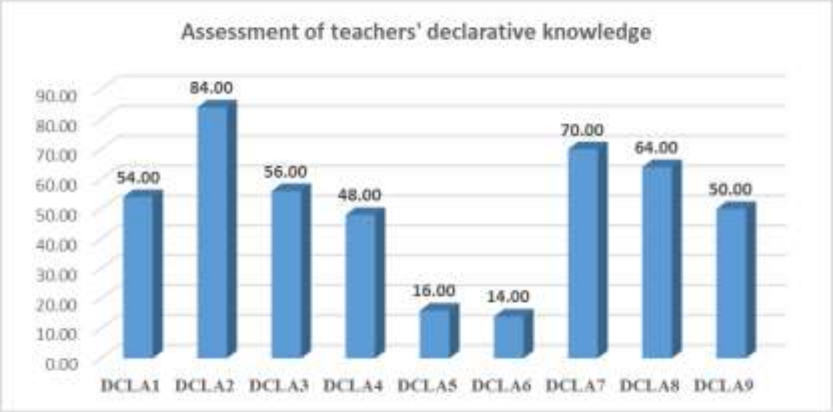

Fig 6: Results of the teachers' declarative knowledge assessment

84% of them know that the relation U = RI is the one translating Ohm's law for an ohmic conductor and barely half of the teachers (56%) recognize the relation U = ER.I as the relation translating the law Ohm for a battery in operation. The overwhelming minority of them can answer the highly crucial training question "what is the use?" »Ohm's law (DCLA 4, DCLA5 and DCLA6) (See graph in Figure 6). In total we can say on the basis of our questionnaire, the teachers seem to have a minimum mastery of factual knowledge (declarative) and reasoning (procedures) about the law of Ohm. On the other hand, teachers experience

Serious difficulties in solving relatively simple problems which are sufficiently distant from those usually encountered in school context and whose resolution requires the use of schematic and strategic knowledge.

4.5. Result of the multivariate analysis

We sought to assess how teachers use declarative, procedural and schematic knowledge to solve problems requiring the mobilization of strategic knowledge for its resolution.

Table 4: Model parameters (%STRA)

Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)	R^2
Constant	26,515	8,513	3,115	**0,003**	9,379	43,650	0,049
% DCLA	0,214	0,191	1,122	0,268	-0,170	0,598	
%PROC	-0,003	0,118	-0,029	0,977	-0,242	0,235	
%SCHE	0,072	0,171	0,423	0,675	-0,272	0,417	

Given the value of the total coefficient of variance (R = 0.049), only 5% of the variability of the dependent variable strategic knowledge is explained by the three variables declarative, procedural and schematic knowledge.

Table 5: Model parameters (%SCHE)

Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)	R^2
Constante	18,276	6,644	2,751	0,008	4,910	31,642	0,148
% DCLA	0,198	0,142	1,395	0,169	-0,088	0,485	
%PROC	0,118	0,094	1,255	0,216	-0,071	0,306	

Thus only 15% of the variability of the schematic knowledge variable is explained by the explanatory variables declarative knowledge and procedural knowledge.

From Table 5 we can plot the average percentage success rate for each of the four variables under study. Figure 5 shows that teachers have a minimum mastery of declarative and procedural knowledge regarding Ohm's law. On the other hand, they only manage to a lesser extent to answer questions that require the use of schematic and procedural knowledge.

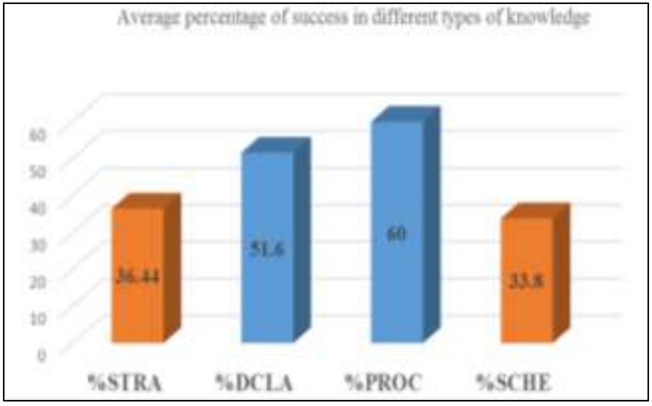

Fig 7: Average percentage of teachers' success by type of knowledge

This result tends to confirm the absence of correlation between superior knowledge, strategic and / or schematic knowledge with inferior knowledge, that is to say, procedural and declarative knowledge about Ohm's law.

On the one hand, multivariate analysis shows that the declarative, procedural and schematic knowledge variables are not correlated with the strategic knowledge variable. On the other hand, the declarative knowledge and procedural knowledge variables have very little influence on the schematic knowledge variable. Teachers do not have full knowledge of the definitions, statements, calculation procedure relating to Ohm’s law. We think that this could justify why teachers find it difficult to assert regulatory knowledge for which they constitute prerequisites.

Conclusion

This research was interested in exploring the knowledge of some Beninese teachers concerning Ohm's law in an extra-curricular context. The results tend to show that even if teachers have factual and procedural knowledge about Ohm’s law, they do not know or do not mobilize them to solve problems that require schematic and strategic knowledge. These results seem to echo those from the work of Solaz-Portolés and López (2008) [12]. It seems to us that the assessment of declarative, procedural and schematic knowledge does not make it possible to highlight in a teacher the possibility of using them in a concerted manner to solve a complex problem. As Canu (2014) [2] states, "the assessment of declarative and procedural knowledge does not provide information on the operational nature of this, that is, on schematic (and strategic) knowledge". The few teachers in our panel who have succeeded in strategic or schematic questions have not necessarily mobilized procedural and declarative knowledge in a concerted manner. If we start from the principle that a teacher can teach only what he knows, we can conjecture on the fact that the difficulties of comprehension of the law of Ohm by the pupils and those of the teachers in the implementation, in class of this law, find their possible source in the insufficiency of their knowledge about the law of Ohm. This result deserves to be taken into account for the initial training of physical science teachers in Benin. Indeed, the study of Ohm's law in college appears to be central to the learning of physics in Benin insofar as it brings into play an essential concept, that of proportionality. Proportionality allows the study of the calibration of a spring a few months after that of Ohm's law. It will allow, in chemistry to study the concentrations of chemical species in solution, then from the following year, in third, the study of the relationship between weight in mass. His intrusions into the heart of teaching and learning at the graduate level are numerous. The challenges for teacher training are numerous. The method that we used to collect data based on the questionnaire, although having the advantage of reaching a large number of people and allowing us statistical processing, may be cumbersome to exploit. It is coupled with a fragility of responses (superficial, reality, or not, various constraints of the teacher perhaps not allowing him to express himself) which are not always exploitable. It is possible to extend and / or exploit this study by linking with other studies interested in the disciplinary knowledge of teachers (for example via studies around PCK, professional didactic knowledge, etc.).

References

1. Anderson jr. Acquisition of cognitive skill. Psychological review. 1982; 89(4):369-406.
2. Canu m. Contribution of the joint study of free dynamic systems and controls in the understanding of the concepts of balance and stability, Doctoral thesis, Diderot University Paris 7; Universidad Los Andes, Bogota, 2014.
3. Herl he, O’neil hfo, Chung GKWK, Bianchi C, Wang SL, Mayer R, et al. final report for validation of Problem-Solving Measures National Center for Research on Evaluation, Standards and Students Testing. Los Angeles, 1999, 1522(310).
4. Liegeois L. Mullet E. High school students' understanding of resistance in simpleseries electric circuits, International Journal of Science Education. 2002; 24(4):551-564.
5. Malafosse D, Lerouge A, Dusseau JM. Interdisciplinary study of mathematics and physics of the acquisition of Ohm's law in college: space of reality, Didaskalia. 2000; 16:81-106.
6. Malafosse D, Lerouge A, Dusseau JM. Study in inter-didactics of mathematics and physics of the acquisition of Ohm's law in college: change of framework of rationality, Didaskalia. 2001; 18, 61-98.
7. Malafosse D, Lerouge A, Dusseau JM. Change of semiotic registers in didactics of physics: example of Ohm's law in college. Skholê special issue, 2001, 11-17.
8. Malafosse D, Dusseau JM. You said:"U=R.I"? Bulletin of the Union of Physicists. 2001; 95:685-705
9. Periago C, Bohigas X. A study of second-year engineering students' alternative conceptions about electric potential, current intensity and Ohm's law, European Journal of Engineering Education. 2005; 30(1):70-94.
10. Ruiz-Primo MA, Shavelson RJ. Problems and issues in the use of concept maps in science assessment. Journal of Research in Science Teaching. 1996; 33(6)569-600.
11. Shavelson RJ, Ruiz-Primo MA, Wiley EW. Windows into the mind, higher Education. 2005; 49:413-430.
12. Solaz-Portolés JJ, López SV. Types of knowledge and their relations to problem solving in science: directions for practice, Educational Science Journal. 2008; 6:105-112.
13. Vergnaud G, Halbwachs F, Rouchier A. Structure of the material taught, history of science and conceptual development in the student, Revue Française de Pédagogie. 1978; 45:7-15.