International Journal of Innovation and Research in Educational Sciences
Volume 4, Issue 2, ISSN (Online): 2349–5219

Difficulties Encountered by Moroccan Student in Studying Oxydoreduction

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Date of publication (dd/mm/yyyy): 06/03/2017

Abstract — **Learning oxidation-reduction reaction may abut a large number of obstacles. Beyond the fact that the concepts are numerous and unfamiliar to students alternative designs within the previous knowledge of these may affect their understanding of oxidation and reduction concepts. This work aims to explore the various obstacles and difficulties among Moroccan students on basic concepts (chemical reaction) that constitute an obstacle to the understanding and the basic concepts of the atomic model (ion, cation and anion), and used to interpret oxidation or reduction. redox couple and the balance equation. Studies conducted on this subject have shown in the majority of learners that there are many unresolved problems.**

The originality of our educational study is that we have proposed for the first time a path between oxidation, reduction and the electronic structure of atoms, simple molecules to clarify the redox phenomenon and achieve an effective symbolization the balance equation in learners.

Keywords — **Oxidation Reduction, Concepts Of Oxydoreduction, Ox/Red Couples, Half-Equations, Balance Equations, Pedagogical Languages, Pedagogical Communication, Textbook, Teachers, Pupils.**

I. INTRODUCTION

Both in Morocco and abroad, the concept of oxydoreduction is difficult for teaching and learning. It is one of the most difficult concepts to be assimilated by pupils who still have problems in differentiating an oxidation reaction from an oxidation-reduction reaction because the notions of oxidant and reducer are not assimilated.

In Morocco, pupils of the 1styear Baccalaureate in experimental sciences and Mathematics streams study the oxydoreduction chapter for the first time in the second semester. The basic concepts of atomistic have been dealt with in common core(1styear Baccalaureate) :Bohr's atomic model, Lewis model, ionic bonds, covalent bonds, polar bonds, etc; which facilitates understanding of the notion of electron transfer. In the 2ndyear, pupils, exploit the basic concepts of oxydoreduction already seen in the first year to be able to measure the speed of reaction of a slow transformation during an oxydoreduction dosage(Reaction balance, half redox equation, couples ox / red) and to predict the direction of evolution of a chemical system (chemical batteries ...). The fact that the teaching / learning of oxydoreduction is almost based on a single model, that of the transfer of electrons in the secondary classes, whereas the concept has four process models which constitutes one of the blocking factors[1]. This lead us to ask how we can teach oxydoreduction to gain a sustainable and functional knowledge by taking into consideration the conceptual difficulties that learners show for its basic concepts. The research results [1-6] lead us to focus on the conceptualization process to implement the teaching of oxydoreduction.

Moroccan teachers had initial training for only three years of university education and a year of training at the CRMEF (Regional center of education and training),followed by some courses in class during the pre-service within the supervision of mentors. In addition, there are few ongoing training devoted to the teaching of oxydoreduction. As a result, their situations of teaching / learning are simply constructed in accordance with the organization of contents of the textbook.

Interviews and surveys conducted among high school teachers evoke the same difficulties and the same obstacles: lack of practical work (students do not have the opportunity to handle chemicals, observe chemical reactions), overloaded curriculum (No application exercises) ... The CRMEF trainee teachers of Casablanca at the onstage professional activity (MSP) and during the first session of observations found that the majority of students in the 1stBaccalaureate do not understand the concepts oxidation, reduction and have difficulty in determining Ox / red couples. As for the pupils of the 2ndyear, they find it difficult to predict the ox/red couples involved in an oxydoreduction and therefore have difficulty in writing the half-equations and inferring the balance equation. They also found that some teachers do not find enough teaching languages to convince the student.

In the current study, we propose to search for and identify the determining factors in the lack of understanding of the concepts of oxydoreduction among learners in the secondary education. For this reason, we have conducted an exploratory research around the main actors in the pedagogical learning process (textbooks, teachers and pupils).

II. METHODOLOGY

This study attempts initially to identify, via the official instructions, the official book of instruction and textbooks of secondary school, what knowledge is to be taught and how is it organized? What are the indications that can guide the teacher to organize learning activities? What is the level of understanding in the pedagogical communication between the teacher and the pupils?

To answer these questions, we first conducted an analysis of the aforementioned documents, followed by interviews and questionnaires (tested and approved) to determine the uses of teachers for these concepts in class. The methodology adopted in this research is based on the following three parts:

Part 1: Curriculum of chemistry of secondary school "oxidation-reduction chapter".
Part 2: The teaching skills acquired by Chemistry teachers.
Part 3: Pedagogical communication between the teacher and the students in chemistry presentations in high school (Measuring the effects on student learning).

III. Analysis of the Content of Textbooks in Consultation with Official Instructions.

In order to explain some of the difficulties that learners may have in appropriating the basic concepts of oxidation reduction, we will present briefly the results of the analysis of the chemistry textbooks "oxidation-reduction part" of the teaching in the secondary level (common core level, 1st and 2nd year baccalaureate). We also offer to compare the organization, complementarity and articulation of different atomistic concepts and oxidation reduction in the teaching skills.

Question: To what extent can a pupil, at the end of the secondary level, give the balance equation of an oxydoreduction reaction, can differentiate between reduction, oxidation, identify the couples involved and predict the nature of such a reaction?

The analysis of the content of school textbooks could shed light on the way in which are introduced the basic concepts oxydoreduction to learners and possibly on complementarity and the manner in which they are articulated.

III.1. Chemistry School Textbook "oxydoreduction chapter" Common core level (1 secondary level):

The knowledge of atomistic, considered as fundamental in the understanding of the concepts of oxydoreduction, is part of the program of the common core. They are introduced below:

- Model of the atom: nucleus, electrons: number of charge and atomic number Z, number of mass A, elementary electrical charge, charge of constituents of the atom, electroneutrality of the atom.
- Chemical element: definitions of mono atomic ions, characterization of the element by its atomic number and its symbol, conservation of the element during chemical transformations.
- Model of the electron particle: distributions of the electrons in different layers K, L, M, distribution of the electrons for the elements with atomic number Z between 1 and 18.
- The Duet and octet rules:
- ✓ Stability rules for noble gas atoms, chemical inertia.
- ✓ Application to stable monoatomic ions.
- ✓ Application to molecules using the Lewis model of the covalent bond, Lewis representation of some molecules, enumeration of bonding and non-binding electron doublets.
- Modeling the chemical transformation of a system (chemical reaction, initial state and final state of a system), symbolic writing of the chemical reaction (equations, reactants and products)and adjustment of stoichiometric numbers.
- Material balance.

III.2. Chemistry School Textbook "oxydoreduction chapter" Level 1st and 2nd year Baccalaureate:

The new concepts introduced, which can be mobilized to explain the formation of the bond during a chemical transformation, are introduced as follows:

- Examples of oxydoreduction reactions as reactions involving electron transfer (action of hydrochloric acid on a metal).
- Writing of each reaction and definition of an oxidant and a reducing agent.
- Definition of a reducing oxidizing couple.
- Method and formalism for writing the equation of an oxydoreduction reaction.
- Use of the periodic table to give examples of reducing and oxidizersagents.

The analysis of the content of the textbooks of the three levels of the secondary school in consultation with the official instructions which allows us, for the 1st year and 2nd year baccalaureate, to find that:

- The hourly volume intended by official instructions to certain chapters is not proportional to the volume of the content of textbooks.
- The concepts present in scientific knowledge differ from those of the knowledge to be taught: there are no concepts of oxidation number and electro negativity at the level of the knowledge to be taught.
- There is no scale of reference potentials.
- The articulation between the different chapters of the content of the textbook level 1st and 2nd year baccalaureate is not adequate to achieve a good illustration of the concept oxydoreduction.
- The program of the 2nd year Baccalaureate in the last chapter "electrochemical cell" has a more or less appropriate microscopic description but remains insufficient for the lack of the Nernst equation.

III.3. Results and Discussion:

In class of the secondary level, the student facing an oxydoreduction reaction should recognize and represent the half-equations of oxydoreduction. Thus, the transition from experimental observation to modeling through the use of atomic and molecular scales requires a strong capacity for abstraction and even if pupils master the rules, they can no longer give them meaning. The most contemplated difficulties:

- At the level of the textbook of the 1st year of the Baccalaureate, there is the absence of essential concepts that are decisive in understanding the fundamental concepts of oxydoreduction which are: "qualitative classification of redox couples" and "gamma rule". The first concept allows to quantify each of redox couples according to their oxydoreduction power. It also seems clear that for a given couple, the more strong oxidizer is more its conjugate has a low reducing power. So we can place each couple on a double scale that allows to predict what the tendency of a couple will be reacting instead as an oxidant or rather as a reducing agent. The second concept makes it possible to predict the reactions which will naturally take place and which, on the contrary, are impossible in a normal context. For example: the observation of reality (diagram below: Fig. 1) shows that the redox couples do not react in any way. One would expect indeed to have as well $2Al + 3Cu^{2+}$ □ $+ 3Cu$. However, observation shows that this is not the case. The first reaction obviously works: there is discoloration of the copper solution and the metal copper will appear on the aluminum which is gnawed. Conversely, the second experiment does not lead to any reaction.

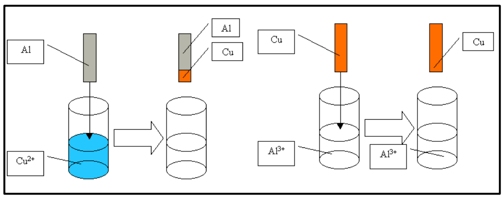

Fig. 1. Diagram of reaction Al/Cu^{2+}

- The absence of the "oxidation number" concept is also noted. The learner, when dealing with molecular compounds, when outside the aqueous solutions, cannot define the oxydoreduction reaction from the writing of two half-equations which translate complete exchanges of electrons between oxidant and reducer. This definition does not apply and only the technique of oxidation numbers is applicable in this case. For example, the chemical formula of iron ore (present, for example, in hematite) is Fe_2O_3, the oxidation number of iron in this substance is + III. To obtain iron from its ore involves transforming into Fe^{3+}, it is therefore a oxydoreduction reaction. The reducing agent used is CO, obtained by burning the coke in the blast furnace. The overall reaction is as follows: $Fe_2O_3\ (s) + CO(g) \rightarrow Fe(s) + CO_2\ (g)$.
- At the level of the program of the 2nd year, we note the non-existence of the notion "potential of the redox couples" which predicts the spontaneity of a reaction. Understanding the spontaneity of a reaction is fundamental in chemistry because it is the basis for the operation of electrochemical cells, for example, the oxidation of iron (Fe) by the oxygen in the air to form hematite (Fe_2O_3)

$4Fe + 3O_2 \rightarrow 2\ Fe_2O_3$ (oxydo-reduction)

Can be written: $4Fe \Leftrightarrow 4Fe^{3+} + 12e^-$ (oxydation)
$3O_2 + 12e^- \Leftrightarrow 6O^{2-}$ (reduction)

Both couples are Fe^{3+}/Fe and O_2 / O^{2-} ; the potential of O_2 / O^{2-} is higher than that of Fe^{3+} / Fe. In addition to the 2nd year baccalaureate there is also a microscopic description more or less appropriate when performing an electrochemical cell but is still inadequate since the Nernst equation is not in the program. Indeed, the latter has a decisive role in determining the electromotive force of the battery, predicting the direction of movement of balance, the direction of the electric current and the identification of the redox couple that undergoes reduction and oxidation.

III. 4. Conclusion 1:

The content of textbooks of chemistry "oxydoreduction chapter" of the 1st and 2nd year of secondary school as a whole is not well structured (discontinuity, disconcordance paragraph, non-articulation, hours of teaching...) so a good illustration of the oxydoreduction concepts depending on the three registers. The absence of essential concepts which are decisive in understanding the fundamental concepts of oxydoreduction which are: "the qualitative classification of redox couples", "the gamma rule" and the number of oxidation for the 1st year level and "Potential of redox couples", Nernst's law for the 2nd year level is the source of enormous obstacles found by the learners.

This deficiency noted in the textbooks for the two levels plus the hourly volume intended by official instructions to certain chapters which is not proportional to the volume of the contents of textbooks, pushes teachers sometimes to increase the number of hours to complete the program.

The effect of this multiplies the number of difficulties of understanding of the concepts of oxydoreduction and decreases the rate of the teaching performance. Better textbooks accompanying suitable official instructions would greatly facilitate the work of teachers and would enable students to work more effectively and with interest, and even for some with more pleasure.

IV. THE TEACHING OF THE CONCEPT OF OXYDOREDUCTION IN SECONDARY EDUCATION IN MOROCCO: PROFESSIONAL KNOWLEDGE OF TEACHERS.

As a first approach to this work, we started by identifying the "conceptions" of teachers. Among the possible methods of investigation in didactic research (questionnaire paper / pencil, observation of practices in class, interview ...), we favored the interview method. This method seems to offer a great autonomy of expression (language and gesture). It allows obtaining a good idea of the conceptions of the interviewees, since producing nothing written which can serve as a reference in order to better structure their answers, can (or risk) to repeat, to split up, to speak about related subjects, etc. The answers that the teachers will produce during the interview would be closer to the discourse they hold in class than those they would have structured in writing. They, therefore, provide rich information, even if they are sometimes difficult to treat because of their dispersion. To limit this risk, we opted for an interview, based on a series of four questions chosen according to a gradation from the implicit to the explicit about the links between the concepts involved.

The sample is made up of 36 teachers of Chemistry for secondary levels, all having a master's degree in chemistry or physics with at least 20 years of seniority. The duration of the interview has not been fixed before. It varied from 15 to 45 minutes, depending on the teacher (interaction between teacher and researcher). All the interviews were recorded using a tape recorder and were subsequently transcribed in order to constitute the corpus of our study. Using the questions (Qi) which formed the backbone of the interview, we sought to analyze what were their:

- Disciplinary knowledge, that is, the conceptions that teachers have of the concept of oxydoreduction and its symbolization by the reaction equation.
- Pedagogical knowledge, especially their methodological choices to address teaching objects of knowledge concerning the knowledge to be taught.
- Didactic knowledge, learning difficulties that students may encounter and how to take them into account.
- Viewpoint on the content of school textbooks (what is the knowledge to be taught and how is it organized?).

IV.1. Professional Knowledge of Teachers

Q. 1: Have you benefited from ongoing training in teaching the four teaching models of the concept of oxydoreduction: oxygen transfer, hydrogen transfer, electron transfer and variation of the number of 'oxidation?

Figure 1 show that the majority (80%) of teachers have never received training devoted to teaching the concept of oxydoreduction and often their teaching / learning situations is simply constructed in accordance with organization of the contents of the textbook and official instructions. On the other hand (15%) of teachers have received a short training (3 to 5 days) which is still insufficient. Other teachers (5%) consider that they have resorted to self-training.

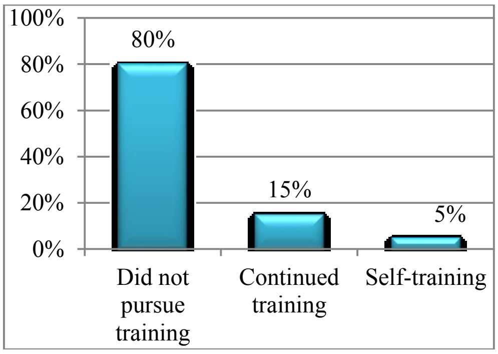

Fig. 1. Percentage of physics teachers who have been trained

Q. 2: Do you integrate technologies (TICE, EXAO, simulation software ... etc) to introduce the concept-processes of oxidation and reduction in your teaching?

The results revealed that 76% of the teachers being questioned have never integrated the technologies (TICE, EXAO, simulation software, etc.) into their teaching of the process concept of oxidation and reduction (Figure 2) because of lack of training or lack of adequate computer equipment in institutions. On the other hand, in France, technologies (TICE, EXAO, simulation software ... etc) are one of the most widely used in French secondary schools from 1993 [7]. TICE, EXAO, simulation software, etc.) are very practical to teach chemistry and physics and empower students, they are able to develop the learner's initiative and value[8]. Thus, learners can visualize the representations and the organization of knowledge while taking charge of scientific contents [9].

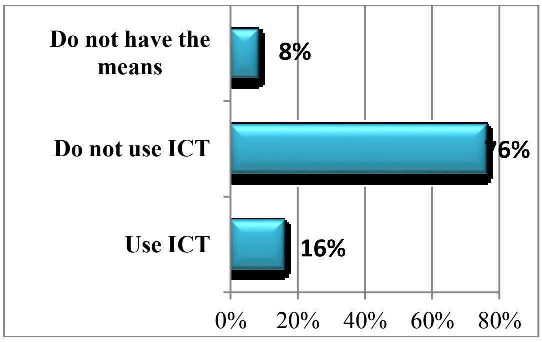

Fig. 2. Percentage of physics teachers integrating ICT in classroom.

Other teachers (8%) consider that it is rather the lack of time and/or the overload of the classes which hinder the use of the technologies (TICE, EXAO, simulation software ... etc). Less than one-sixteenth (16%) of the teachers being surveyed felt that incorporating technology into teaching facilitates the task and increases student motivation, and considers that technology enhances learning and helps to improve teaching. Also, the use of technologies (TICE, EXAO, simulation software, etc.) helps to reduce task and save time especially in the realization of experiments. It increases students' interaction, and promotes understanding, distinction and differentiation between the four teaching models of the concept of oxydoreduction: oxygen transfer, hydrogen transfer, electron transfer and variation of the oxidation number. It also encourages the construction of new scientific concepts.

Q. 3: Do you use textbooks and official instructions (teaching guidelines) or other resources when teaching the concept-processes of oxidation and reduction?

Figure 3 shows that half (50%) of the teachers interviewed use the textbook in their teaching and declare that it remains insufficient and that a didactic analysis of the content of the textbook showed the existence of gaps (lack of certain complementary concepts which hinder the adequacy of learning. In order to reinforce the learner's learning in the most difficult situations or in the case of lack of material to carry out an experiment, for example, they use other documents (scientific text, pictures of certain experiments, simulation software ...). On the other hand, only (20%) of teachers consider the textbook as the only source of information and consider that it is sufficient for their teaching for the secondary levels. At the same time, almost a third (30%) of teachers believe that the articulation and linking of the different chapters of the textbook content is not adequate to give a good illustration of the course and that there is inadequate necessary chemical background to fully describe the concept of oxidation-reduction processes in the microscopic and macroscopic registers.

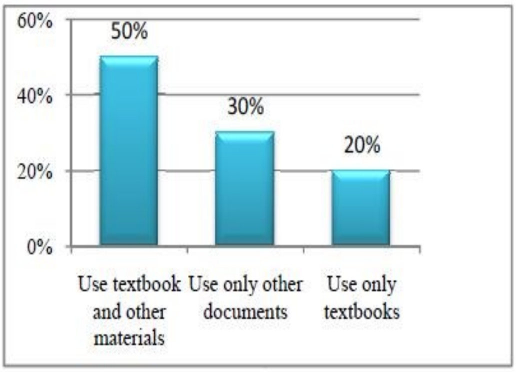

Fig. 3. Percentage of physics teachers using textbooks.

In other words, almost all the teachers have declared the absence of essential concepts that are decisive in understanding the fundamental concepts of redox which are: "qualitative classification of redox couples", "the rule of the gamma "And the oxidation number for the 1styear baccalaureate and" redox pairs potential", Nernst's law for the 2ndyear and they use other documents to prepare the course. As for the use of the instructions (Teachers' Guides), the majorities of teachers and the inspectors considered that the time designated in each chapter by the official instructions does not correspond to the content of the latter: the duration indicated in the description of such a chapter is insufficient And that some of the experiments proposed in the official instructions are either incomplete or unfeasible on the practical level of the laboratory, so its use by the teachers in the execution of the courses remains momentary.

Q. 4: How do you define an oxidizer? a reducer? And distinguish the oxidation of the reduction and the oxidant of the reducing agent in wet and dry media?

The majority of the teachers interviewed (80%) spontaneously use the electron transfer model for oxido - reduction and only 20% mentioned the case of oxydoreduction without electron transfer since in some oxydoreduction reactions, especially in the dry phase (ie in a non-aqueous place, often at high temperature), there is no obvious transfer of electrons. For example, the case of the combustion of dihydrogen in the dioxygen of air:

$2H_2 + O_2 \rightarrow 2H_2O$ (gas).

According to Lavoisier [10], the hydrogen element, which was combined with the oxygen element, underwent oxidation. But the reagents H_2 and O_2, and the product H_2O are molecules; No ion, which would allow an interpretation in terms of electron transfer, is present in the chemical species involved.

They seem almost use of indifferent manner to oxred, terms, at first synonymous view, such as gain/accept, transfer/exchange, lose/release, assign/give, as each term is mobilizing a different representation of the process of oxydoreduction. All the teachers interviewed do not explicitly mention any other type of transfer (total electron transfer between atoms: formation of an ionic bond, partial electron transfer, polarized covalent bond, ion covalent bond, etc.).

Only 5% of the teachers interviewed mentioned that the teaching / learning of oxydoreduction are almost centered on a single model of electron transfer in secondary classes, whereas the concept has four process models of oxydoreduction: transfer of oxygen, hydrogen transfer, electron transfer and variation of the number of redox. They are aware of how we can teach oxydoreduction considering the conceptual difficulties of learners about the basic concepts of oxydoreduction to gain a sustainable and functional knowledge. On the basis of this professional knowledge, these teachers have proposed in a clear and satisfactory way the distinction of oxidation and reduction and oxidant of the reducer in wet and dry environment.

IV.2. Conclusion 2:

This study has highlighted the existence of difficulties for most of the actors in the process of educational pedagogical learning which are of disciplinary, didactic and pedagogical origin. These difficulties make it difficult to understand the concept-processes of oxidation and reduction: the representation of a reducing oxidizing couple by its symbol or its formal equation, writing the equation of an oxydoreduction reaction, the distinction between oxidation and reduction, oxidant and reducing agent and differentiation between a half reaction and an oxydoreduction reaction. These difficulties also lie in the absence of essential concepts which are decisive in understanding the fundamental concepts of redox, which are: "qualitative classification of redox couples", "gamma rule", number of oxidation for Level 1styear baccalaureate and "potential of the redox couples", law of Nernst for the 2ndlevel baccalaureate.

The percentage (15%) of teachers of physics integrating the technologies (TICE, EXAO, simulation software, etc.) in their teaching of the concept-process of oxidation and reduction is insufficient given the importance of technology: It changes the role of the teacher and that of the class which becomes a learning center to learn by building, navigating, typing with the computer. Thus, learners can view the performances and organization of knowledge while supporting scientific content.

V. THE TRANSMISSION (TEACHING COMMUNICATION) OF KNOWLEDGE TO PUPILS DURING THE TEACHING OF OXIDOREDUCTION AT THE SECONDARY LEVEL. MEASURING EFFECTS ON STUDENT LEARNING

De Vecchi and Giordan [11] propose the following steps to identify concepts for students:

- Let students draw.
- Ask them questions (written or oral) on the explanation of facts that one can meet daily.
- Ask them to explain a diagram taken from a book.
- Place them in a situation of reasoning by the "negative".
- Perform in front of them experiments and ask them questions.
- Realize an experience before them and ask them how the results can be explained.

- Ask them to choose from different analog models.
- Set before apparently contradictory facts and let them talk.
- To play role plays.
- Ask for the definition of certain words.
- To confront the class with a conception emitted by a pupil or even with an explanation drawn from the history of science.
- And finally, be constantly listening to the students: the conceptions emerge at every moment of a process.

The oxydoreduction concepts play an important role in the chemistry education in different secondary and university levels where learners find it difficult to understand and assimilate the concepts. In order to identify the different difficulties and obstacles encountered by the students on these concepts, we have developed a course evaluation and a questionnaire containing a dozen questions. The experiment is carried out at the level of the secondary level. A questionnaire is designed for students of the first year baccalaureate; stream: experimental sciences and mathematics (N = 180 students) and the second year, stream: science experiments (N = 160 students) to explore the various difficulties and obstacles encountered by students on concepts of oxydoreduction. The pupils had tackled the concepts of atomistic in their school curriculum, which was essential to answer the questionnaire. In the second phase, students have, for the first time, studied the basic concepts of atomistic, which already allow them to answer a question involving electron transfer. On the other hand, they did not discuss the use of these concepts in the specific field of oxydoreduction. In the first year of the secondary level, the oxydoreduction is addressed for the first time.

V.1. Course Evaluation

We agreed with the teachers of the selected high schools, the choice of three different courses of oxydoreduction chemistry. The duration of these courses varies from 1 hour 30min to 2 hours which are followed and filmed by the trainee professors. Then, the professor's oral message was completely transcribed on the basis of the filmed lessons. The information recorded on the board or on the teacher's record also been fully transcribed.

Each course covers one of the common chapters, claimed by the teachers as important in the training of pupils of 1st and especially of the 2nd year of the secondary level. The contents of the three chapters:

Chapter 1: oxydoreduction concepts: oxidation, reduction, and half redox equation.
Chapter 2: oxydoreduction reactions (Notion of chemical reaction, laws of the chemical reaction, writing and balancing of a chemical equation).
Chapter 3: qualification of redox couples (prediction of possible oxidation-reduction reactions).

V.2. Development, Progress and use of Questionnaires

The three questionnaires developed in collaboration with teachers, each carry on one of three courses selected by high school. These questionnaires contain a series of common items using the teacher's notes to which students must answer individually. These items aim to measure the degree of deep understanding of the concept-processes of oxidation and reduction and how pedagogical communication is passed between the teacher and his students. Table 1 shows the rate of student participation in each questionnaire within two years of research (2014-2015).

Table 1: Distribution of the three questionnaires for pupils of the high secondary schools during the two years of research

Characteristics	Chapiter 1		Chapiter 2		Chapiter 3	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Number of students enrolled in the course	436	418	436	418	436	418
Rate of questionnaires completed*	72%	76%	49%	67%	48%	69%
Rate of incomplete questionnaires **	6%	11%	3 %	2%	6%	9%
Rate of unreliable questionnaires **	6%	2%	7%	1%	11%	7%
Rate of valid questionnaires **	56%	91%	94%	97%	92%	9%

* Percentages calculated in relation to the number of students enrolled in the course.

** Percentages calculated in relation to the number of completed questionnaires.

The overall score for each completed questionnaire was allocated as follows: the expected response for each question was subdivided in response element and characteristic of the response-related to assumptions. A rating of "1" is granted for a full answer, a score of "½" for an incomplete response element and a score of "0" when the response element is incorrect. A sum of the scores assigned to the answer items is calculated per question and finally the total scores for the entire questionnaire are calculated. This score will be considered as a reflection of the student's actual understanding of the subject.

Finally, the questionnaires which appear to be very laconic and which were therefore completed by students who obviously invested little in the activity were eliminated from the analysis. The criterion arbitrarily chosen is the following: no answer to half or more than half of the questions. It does not cover more than 4 to 6% of students (Table 1).

V.3. Results and Discussion

a. Effectiveness of the Message sent to Students:

The results show that, in general, the level of teachers' awareness of their own communication behaviors is very limited, and even more so when it comes to detecting, decoding and interpreting their own nonverbal behaviors. In the teacher's verbal didactic discourse, the following was observed (Figure 4):

- The microscopic level is weakly highlighted in the courses and the symbolic level is far from predominant, which was also mentioned by Johnstone (1991) and Gabel (1993)[12-13].

- A particular emphasis was placed on the microscopic level for the course "notions redox oxidation, reduction, and half redox equation" during the second year (16% to 38%).
- An increase in the microscopic level to the other two classes, "Reactions of oxydoreduction (chemical reaction concept, writing the laws of chemical reaction and balancing a chemical equation)" (12% to 26%) and "qualification couples Redox (prediction of possible oxidation-reduction reactions) "(6% to 10%) between the two years.

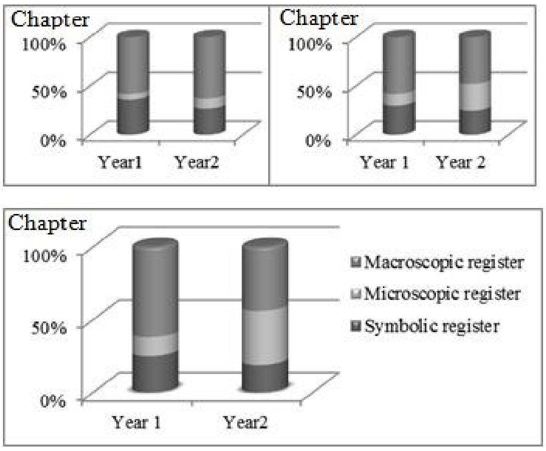

Fig. 4. Proportion of different levels of knowledge in the three chapters

b. Pupil Comprehension Rate After the Course

Students' achievements in relation to the three levels of knowledge are presented in a transversal way for the three questionnaires analyzed. The students' responses were quantitatively analyzed for their ability to identify the level of knowledge and to establish links between two levels. Figure 5 shows the proportion of students who have met the level of knowledge required in the question and who have established links between two levels of knowledge.

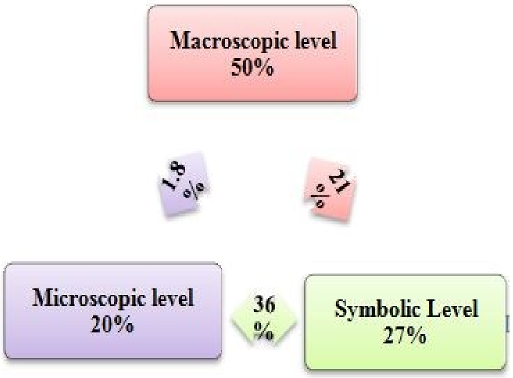

Figure 5: Proportion of students who met the level of expertise required and having established links between two levels of knowledge in their questionnaire responses

For example, for the course of the oxidation-reduction reactions, two experimental experiments were carried out on the macroscopic level to demonstrate the action of hydrochloric acid on the metals M_1 and M_2, to explain microscopically the detection of the existence of the ions M_1^{n+} and M_2^{m+} as well as to register the equations of redox-oxidation solutions.

In this study, we found that learners meet the level of expertise required and establish links between two levels of knowledge in their questionnaires: symbolic writing oxidants and reducers, and the oxydoreduction by an equation which expresses the conservation of the mass at the macroscopic level and that of the atoms at the microscopic level. Almost half of the students respect the macroscopic level in their responses while the symbolic level is respected by less than a third of the students and that the microscopic level is less than a quarter.

Approximately one-third of students correctly establish the links between two levels of knowledge to explain a notion or concept in chemistry: oxidation, reduction, redox half-equation, identification of redox couples, demonstration of ions formed…

It results from this quantitative analysis of the questionnaires that there are clearly gaps in the identification of levels of knowledge and the linking of these levels exists for almost all learners.

Regarding the questionnaire on "Oxydoreduction reactions: oxidation, reduction, and half redox equation", pupils obtained a significantly lower average in the second year than the first year, whereas for the two more questionnaires dealing with the two chapters: "Oxydoreduction reactions" and "Qualification of redox couples (prediction of possible redox reactions)", the pupils obtained a significantly higher average in the second year (Table 2).

Table 2. Results comparing the averages obtained from the questionnaires between year 1 and 2

	years	(average ± Standard deviation)/20
Chapiter1	year 1	12,5 ± 1,7
	year 2	11,2 ± 1,6
Chapiter2	year 1	12,8 ± 1,8
	year 2	15,4 ± 1,6
Chapiter3	year 1	9,9 ± 1,7
	year 2	13 ± 1,5

V.4. Conclusion 3

By studying systematically using different tools, teachers' communication behavior in their reality (teachers' and students' recordings in the classroom) and at the level of performances (questionnaires and interviews), this research highlights the existence of a noticeable difference between what is done and what is said about the use of discursive strategies. We can see that secondary school teachers have great difficulty in "approaching" the curricular contents of the daily experiences of their pupils.

From the above it can be concluded that, in general, teachers are aware of the communication behaviors that take place in the classroom, meaning that they are based on when they appear, interpretations that students make and the objective they aim at in the teaching and learning processes. However, these teachers claim the importance of organizing training sessions about the teaching of

Chemistry, the learning pedagogy and the mastery and the obligation of the use of ICT which have an important role in correcting the representations of learners and in encouraging strong motivation and interaction between pupil-student and pupil-teacher (competency approach).

Finally, we are able to affirm that continuing training for teachers and the introduction of the communication module in the training program for trainee teachers at CRMEF are essential requirements for improving the teaching process and Learning.

VI. CONCLUSION

While it may be difficult to teach all content and their complete definitions to secondary school pupils, this difficulty of didactic transposition should not in fact conceal ignorance of the complete definitions by teachers and policymakers.

Harrison and Treagust [14] recommend that teachers not only expose the concepts they teach but also explain them.

It is particularly important that students hear and understand good explanations to develop the ability to express themselves and to judge the validity of the explanations of others. In a learning process, students who learn to judge the validity and completeness of explanations will also be able to develop their metacognitive skills and reflect on the logical accuracy of reasoning.

If high school cannot be expected to teach the alpha and omega of chemistry, it should at least be expected that teachers will have chemistry knowledge that goes beyond the strict content to teach .It may also be desirable that the Moroccan Secondary School Training Program should not contain errors in the definition of the concepts of chemistry in general, as these errors may be transposed into textbooks and very probably also into classes.

However, to facilitate the learning content that can be set, keep in mind that it is not enough to present a clear definition to students, given the logical reasoning difficulties that many of them [15].Instead of stating the definition of oxydoreduction, teachers should apply to the systematic analysis of the concept, with examples and against-examples and identifying the essential attributes and variable attributes of each definition [16].

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