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Difficulties encountered by the Moroccan high school students at the level of the modelling and the course of a chemical reaction

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Abstract

The aim of this paper is to explore the various difficulties encountered by the Moroccan high schoolers (senior high) as they relate to the modelling of chemical reactions, microscopic concepts (electronic structure of atoms, valence band, valence electron...) and macroscopic (colour change, gas emission...) linked to the chemical reaction; hence the distinction between chemical transformation and physical transformation. All studies on this topic have shown that most learners still suffer from numerous unresolved difficulties in this area. The symbolic register of the balanced equation represents a chemical reaction; its reading can be done at a macroscopic level (observed phenomenon) and/or a microscopic level (interaction of particles, imagined phenomenon). The originality of our study consists of suggesting, for the first time, a progression between both the microscopic and macroscopic phenomena: Lewis structure (Lewis diagram of atoms and molecules), Gram's model, and spatial representation of simple molecules in order to reach a symbolization of a chemical reaction. Consequently, our study was successful in reducing the degree of difficulty of obstacles encountered by learners at the level of symbolization of a chemical reaction by 55% and the representations aligned with the concept of a chemical reaction by 65%.

Keywords: Modeling, chemical reaction, microscopic level, macro-level, symbolization, Lewis diagram, spatial representation, Gram model, high school.

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1. Introduction

Chemistry is a science which deals essentially the study of chemical transformations. A chemical transformation is modeled by a chemical reaction whose symbolic writing is the reaction equation. The chemical reaction is a central concept in the study of transformations of matter. Many researchers are interested in designs that are students of chemical material transformations and the various difficulties they encounter in the different levels of apprehension (Mrabet-Bader, El-Jamali, Aatiq & Talbi, 2008; Barlet & Plouin, 1994; Ben-Zvi, Eylon & Silberstein, 1982). In the first report with the concept of chemical transformation at the level of the third year of the cycle secondary college in Morocco, the main objective is to encourage the students to represent and interpret chemical transformations that can occur between different species. On the level of the first and second year of secondary school college students have a teaching on the chemical transformation which discussed the concepts of: chemical substance identifiable by its properties, molecules made up of atoms, Atom represented by a kernel loaded positively surrounded by a procession of electrons. They need to know that during the chemical transformation, the disappearance of all or part of the reagents and the formation of products corresponds to a rearrangement of atoms within new molecules. The total mass is conserved during this transformation. The reaction equation was introduced from the first reactions encountered, and rules to balance these equations (conservation of the atoms in the reaction, charge conservation when ions) were presented. This college level program is based on the simple description of the phenomena to model the chemical transformation. As wrote Cassirer (1910, p. 243), there is a need in chemistry "condense a lot of relationships obtained through experience in a single expression, the assumption of a single medium with status of thing" (chemical, reagents and products, chemical reaction, element chemical, acid or base, Valencia of the elements, etc.).

Moroccan teachers had only initial training the three years of their university education and a year of training at the CRMEF accompanied by a few courses in the class of a confirmed teacher. In addition, they have never had training devoted to the teaching of the chemical transformation. As a result, most often their teaching/learning situations are simply constructed in accordance with the Organization of the contents of the textbook.

Ongoing research try first to identify what knowledge to teach and how they are organized in official instructions, the official book of instruction and secondary school college textbooks? What are the indications which may guide the teacher for the Organization of learning activities? What is the degree of understanding in educational communication between the teacher and the students.

2. Methodology

To study the processes of concepts transformation chemical and/or physical, its modeling by a chemical reaction, his symbolic writing by the reaction equation in the teaching of physical science, we made an exploratory research in the surrounding of the actors in the educational teaching learning process (textbooks, teacher and student), to determine the uses of these concepts in class-related teachers. The methodology adopted in this research revolves around the following three parts:

Part I*: *Curriculum of the college of chemistry textbooks

We surveyed the contents of school textbooks in chemistry of the three levels of secondary college in conjunction with the official instructions in order to:

- If there is a complementarity, progression and succession in concepts: chemical processing, chemical reaction, symbolization of a chemical reaction and chemical equation;
- Be able to check at what school level which registers are macroscopic, microscopic and symbolic are addressed.

1. Content analysis of textbooks of the levels first, second and third year of College secondary school in consultation with instructions official.

Question: *To what extent a college student can at the end of this round give the balance of a chemical reaction equation and differentiate between chemical transformation and physical transformation?*

The study of the content of the textbooks of the three levels allowed us to note that:

- For the first levels and second year, the content is based on the macroscopic description of a chemical reaction more developed level second year. We note the absence of a microscopic description of the level of the first year and an introduction to the microscopic description (composition of the Atom) appeared towards the end of the content of the textbook at the level second year.
- The hourly volume by official instructions for chapters is not proportional with the volume of the content of school textbooks.
- The basics in the student's first year necessary to understand the description of a chemical reaction in the macroscopic registry remains insufficient.
- The articulation between the different chapters of the content of school textbooks is not adequate to achieve a good illustration of the chemical reaction concept.
- Official instructions apply: student of level second year should be able to give the equation balance of a chemical reaction in literal form (carbon + oxygen → carbon dioxide) as an example.
- For the content of the manual school level third year we note a microscopic description more to the less appropriate but remains insufficient. Moroccans at this level students have only an approach of the constitution of matter (atoms, molecules, their representation by molecular models), the chemical reaction defined as "a transformation during which bodies disappear and new bodies appear" then represented in literal form by a scheme of reaction for example: methane + oxygen → carbon dioxide + water
- Iron + acid hydrochloric → Dihydrogen + ferric chloride.
- The absence of the periodic system of chemical elements chapter that allows to the learner to know the chemical properties of chemical elements, their symbols, their representation by the Lewis model and predict the number of links.
- The official instructions for the level third year, applying "pupil of the level third year must be able to give symbolic writing reagents and products, and the reaction by an equation that translates the conservation of mass at the macroscopic level and that of the atoms at the microscopic level.

2. Results and discussion

In the second class College cycle, the student against a chemical transformation, it should recognize the reaction and to represent. Thus the passage of experimental observation for modeling using the Atomic and molecular scale requires a strong capacity for abstraction and even if students are to master the rules they no longer make sense of them. The envisaged difficulties:

- The difficulty of mastering the concept of reaction which is defined as substances that react and turn into new substance; a few students are likely, even in second to confuse between chemical reaction and physical transformation class.

- The chemical language is a barrier for students, in fact the majority considering difficulties when they must translate the observation of a transformation in one sentence to explain the phenomenon that took place.

- Some students are unable to admit that the gases are chemical substances.

- The translation of the transformation into chemical equation using symbols, poses even a problem:

- Confusion between the chemical equations and mathematical equations, especially because there is not an equality of numbers but conservation of the number of atom.

- Difficulty in distinguishing between the numbers in the formula and the "coefficients".

- The difficulty of understanding the concept of conservation of atoms, especially in chemical reactions of type: $Zn (s) + 2 (H + Cl\ ) \rightarrow H_2(g) + (Zn^{2+} + 2 Cl^-)_{QA}$, where the iron Zn atom is transformed into Zn^{2+}.

- Resistance during the reading of the equation, especially at the microscopic level. For example, an equation of type: $2CuO + C \rightarrow 2Cu + CO_2$, they have no problem saying that "when this chemical reaction, and in stoichiometric conditions, two moles of CuO reacted with a mole of carbon to give two moles of copper and 1 mole of carbon dioxide", but the difficulty is when they will be asked to read at the microscopic level that is : "two molecules of CuO react with a carbon atom to give two copper atoms and a molecule of carbon dioxide.

- The lack of chemical baggage (absence of periodic (properties and symbols of the chemical elements) chapter, model Lewis (provide the number of links...) necessary to fully describe a chemical reaction in the microscopic registry at this level, considering difficulties at learner, this is when it came to represent a chemical reaction by a chemical equation.) A pupil of 3^RD year college which has only the spherical Atom model (completed in second by the existence of a positively charged nucleus around which electrons, move all being neutral) cannot grasp the meaning of compact models of molecules (H_2O, O_2, CO_2, CH_4) that is presented. Therefore the student won't be able pass a representation in literal form to a symbolic representation of a chemical reaction because the concept of the chemical symbol, how atoms are associated... is non-program.

***Part II**: The personal report of teachers' physical sciences knowledge to teach*

With the help of a questionnaire submitted to the 34 physical science teachers of secondary education College, who teach at the level of the first, second and third year and whose seniority varies from 4 to 30 years, eleven delegations of the regional Academy of education and the formation of grand Casablanca and CRMEF, we have sought to analyze that they were theirs:

- Disciplinary knowledge, i.e. designs that teachers have the chemical transformation and its symbolization by the reaction equation;
- Pedagogical knowledge, in particular their methodological choices to address the teaching of the objects of knowledge for knowledge to teach;
- Didactic knowledge, learning difficulties that are likely to meet with students and how to take them into account.

- Point of seen regarding the content of the textbooks of College (what are the knowledge to teach and how they are organized?).

Disciplinary, didactic and pedagogical knowledge

Q $_1$: *Have you benefited from continuous training devoted to teaching the difference between chemical processing, chemical and physical transformation?*

Our study (Figure 1) showed clearly that the majority (70%) teachers of physics chemistry (College) of the eleven delegations of the regional Academy of education and the formation of the grand Casablanca (Morocco) have never benefited from continuing training devoted to the teaching of the chemical transformation of the physical transformation and the chemical reaction and that most often their teaching/learning situations are simply built in accordance with the Organization of the contents of the textbook and the education official. On the other hand (25%) teachers reported that they received a short training (4-5 days) and all are agreements that this training were inadequate. These formations were most of time supervised by teachers and only (10%) have been framed by educational inspectors. Other teachers (5%) consider that the only way it is learning autonomous "by oneself".

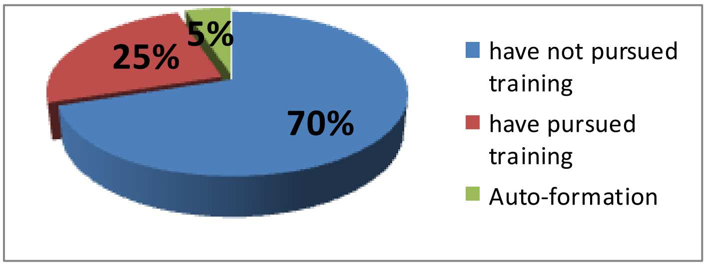

Figure 1. Percentage of teachers of the physical sciences which have undergone training

Q $_2$: *What do you use the CTBT to introduce the concept of chemical processing, chemical and physical transformation in your teaching?*

The results showed that 80% of the surveyed teachers have never integrated the ICT in their teaching of chemical processing, chemical and physical transformation (Figure 2) because of the lack of training or the lack of computer equipment in schools. The number of computers for each institution remains insufficient compared with the numbers of students and is often used for educational management and the preparation of examinations. On the other hand, in France, the CTBT is one of the most widespread in schools and French college from 1993 (Faure - Vialle, 2004). The TICE is very convenient to teach chemistry and Physics makes individuals more student, she is able to develop a spirit of initiative among learner and enhances its possibilities (Mantha et al. 2014). Other teachers (5%) consider that it is rather the lack of time and/or the overload of classes that hinder the use of ICT. Less than a sixteenth (15%) of the teachers surveyed feel that integration of ICT in education easier and improves the motivation of the students, and considers that the TICE reinforce learning and helps to improve the pedagogy of teaching and the use of ICT helps to relief task and time savings especially in the experiments. Adding to this a strong motivation of students, and interaction and promotes understanding, the distinction and differentiation between the concept chemical processing, chemical and physical transformation also promotes the construction of new scientific concept.

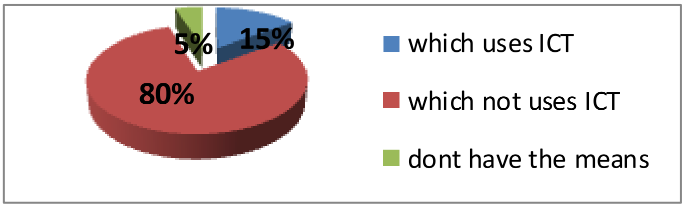

Figure 2. Percentage of physical science teachers integrating ICT in the classroom

Q $_3$: *Do you use textbooks and official statements or other resources?*

Figure 3 shows that half (50%) of surveyed teachers use in their teaching the textbook and declare that there is insufficient. To reinforce learning at the learner in the most difficult situations or in the case of lack of equipment to perform an experiment for example they use other documents (scientific text, photos of some experiments, simulation...). On the other hand only (20%) of teachers consider the textbook as the only source of information and consider that it is sufficient to their college education. At the same time almost a third (30%) teachers see that joint and the linking between the different chapters of the content of the textbook is not adequate to achieve a good illustration of the course and that there is lack of the chemical baggage [absence of periodic (properties and symbols of the chemical elements) chapter, model Lewis (provide the number of links...)] necessary to fully describe a chemical reaction in the microscopic registry at this level envisages a fix at the student, is when it came to represent a chemical reaction by a chemical equation and as a result they use other documents to prepare the course.

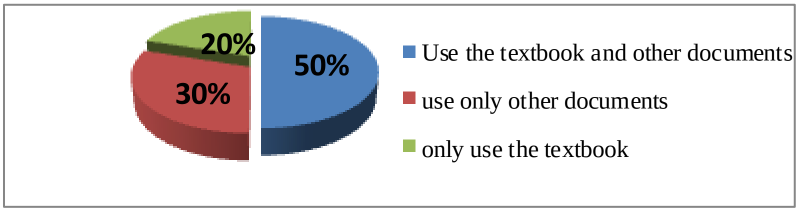

Figure 3. Percentage of physical science teachers using textbook

Q $_4$: *What difference do you see between chemical transformation, physical reaction and chemical equation?*

Teachers really have difficulties to define the chemical transformation. In accordance with the text of the knowledge to teach for 12 per cent of teachers, it is the same thing as the reaction. The term transformation is only reserved for a physical transformation, or perhaps physical transformation (change of State) or chemical (reaction). Finally 12% teachers equate the transformation to a change and 6% said that it was a change of nature of the substances. With regard to the chemical reaction, it is set, in accordance with the definition given in the instruction manual, in terms of transformation in which there are endangered and appearance of body (18% of teachers) of reagents and products (12% of teachers): chemical transformation and chemical reaction are the concepts for these teachers. For 18% of other teachers, the chemical reaction corresponds to a change of reagents in product, which is more in line with what it represents effectively. 50% of teachers, "a chemical reaction corresponds to a rearrangement of the atoms". There is no confusion between the reaction that models the transformation at the macroscopic level and its symbolization, the equation of reaction, which must be balanced (and not the reaction) and that can actually be read at the microscopic level. Regards the chemical equation, 35% of teachers have not indicated what it represents for them. 47% teachers is a representation, a writing, a symbolization of the chemical reaction, "which gives information us on mixtures and products obtained" (18% of teachers) or allows a "quantitative study of the reaction".

Part III**: **Educational communication between teacher and students in chemistry at college presentations. Measuring the effects on the students ' learning.

Originality of this study

To examine the contents of the textbooks for the first, second and third year of secondary school college levels and look how it is structured and find out to what extent it will contribute to a good implementation of the chemical transformation concepts its modeling by a chemical reaction his symbolic by the reaction equation writing and be able to measure the degree of understanding in teaching between teacher and student communication. Project of end of study (PFE) made on this last point with 8 trainee teachers of the section physical chemistry at Ghent Casablanca CRMEF. The subject of these projects aims to measure the degree of deep understanding of the concepts transformation chemical, physical and chemical equation and the manner in which the educational communication is passed between Professor and students. We give subsequently that the main results of this study.

1. Research methodology

In the present work, we have attempted to test this hypothesis by comparing performance in chemistry on three chapters (physical transformation of matter, Reactions chemical and properties of certain substances) with two classes third secondary college of respectively 18 and 22 students on the part of the chemistry program "chemical reactions". This research was conducted in collaboration with three professors of the course of chemistry 1^{era}, 2^{nd} and 3^{RD} of the secondary college, in two public colleges of the provincial delegation of anfa of the regional Academy of education and the formation of the grand Casablanca (Morocco).

Objectives

More specifically, to our hypothesis, we will answer the following questions:

• *Under what conditions does an educational message that emphasizes microscopic registry influence deep understanding of chemistry?*

• *What educational actions during oral presentations allow insisting on the microscopic registry?*

2. Selection of the courses

Three different lessons from the chemistry course were selected in agreement with the teachers, in each of the two colleges. These lessons last from 1 hour 30 min to 2 hours. Each of them focuses on common chapters, judged by teachers as important in the formation of 1^{era}, 2^{nd} and including the 3^{RD} year of secondary school college students. The first chapter concerns physical transformation of matter, the second deals with chemical reactions and a last covers the properties of certain substances.

3. Compliance courses

Each of the selected courses were followed and filmed by trainee teachers. Then the oral message from the professor was fully transcribed on the basis of the filmed lessons. Information noted in table or on the form of the Professor has also been fully transcribed.

4. Development of questionnaires

Three questionnaires were developed in collaboration with teachers. They cover each of the three courses selected by college. These questionnaires contain a series of common items constructed based on what teachers think that students should know and know-how at the end of their course, using their lecture notes. These items are intended to measure the degree of understanding of the physical transformation of matter concepts, chemical reactions and properties of substances and how educational communication is passed between the teacher and the students. They are partly oriented toward our assumptions, the ability of students to move from one level of representation of chemistry to another or to describe specifically one of the levels.

5. Progress of questionnaires

These questionnaires have been distributed to all students in each group of each college, present at the meeting of each lesson courses, at the end of the course. In addition, it was asked to respond individually, carefully and as frankly as possible using their lecture notes. Table 1 shows the participation rate of students to each questionnaire during the two years of research (2013-2014).

Table 1. Distribution of students to the three questionnaires, for the two colleges and for the two years of research

No. questionnaire	Features	Year 1	Year 2
	Number of students enrolled in the course	336	318
1. physical transformation of matter	- Number of completed questionnaires *.	112 (33%)	159 (50%)
	- Number of incomplete questionnaires *.	13 (4%)	17 (11%)
	- Number of unreliable questionnaires *.	9 (8%)	7 (2%)
	- Number of valid questionnaires *.	97 (87%)	144 (91%)
2. Chemical reactions	- Number of completed questionnaires *.	106 (31%)	144 (45%)
	- Number of incomplete questionnaires *.	3(2.8%)	3 (2%)
	- Number of unreliable questionnaires *.	8 (7%)	2 (1%)
	- Number of valid questionnaires *.	100 (94%)	140 (97%)
3. properties of certain substances	- Number of completed questionnaires *.	105 (31%)	145 (46%)
	- Number of incomplete questionnaires *.	6 (6%)	13 (9%)
	- Number of unreliable questionnaires *.	12 (11%)	10 (7%)
	- Number of valid questionnaires *.	97 (92%)	125 (9%)

* Percentages calculated by the number of students enrolled in the course

* Percentages calculated by the number of completed questionnaires

6. Use of questionnaires

Questionnaires completed by students and corrected by trainee teachers have been encoded in an Excel file which includes:

- The personal data of students requested in the first part of the questionnaire;
- The scores for responses to issues relating to the subject-matter.

7. Questions on material

An overall rating for each completed questionnaire has been attributed in the following manner: the answer for each question has been subdivided in response elements and characteristics of the response associated with the assumptions. A '1' rating is granted for a full response element, a note of "½" for an incomplete response element and a note from '0' when response element is incorrect. The sum of the scores assigned to the response elements is calculated by question and ultimately the total of notes for all of the questionnaires are completed. This note will be considered as a reflection of the real understanding rate of the student towards the material. Finally, questionnaires that appear as very terseand therefore completed by students who obviously have little invested in the activity were eliminated from the analysis. The arbitrary criterion is the following: no answer to half or more than half the questions. It covers no more than 4 to 6% of students (Table 1).

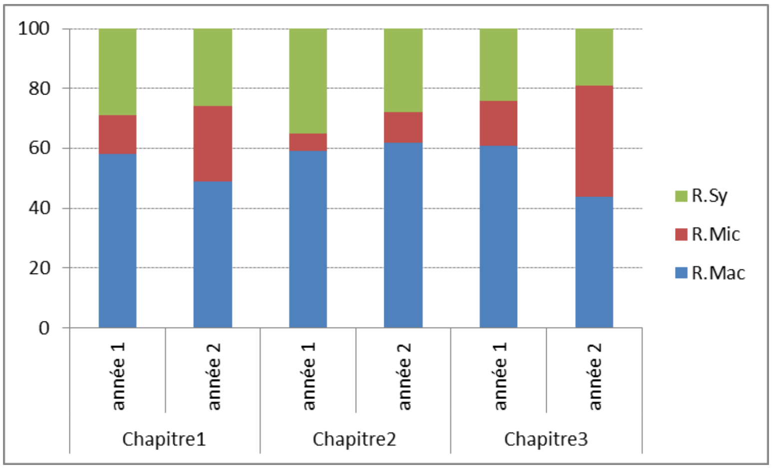

Figure 4. Proportion of the different levels of information within the three chapters in the two years to the two colleges

R. Sy : Symbolic register
R. Mic : Microscopic register
R. Mac : Macroscopic register

8. Results and discussion

a. Characteristics of the message sent to students (Characteristics of the course): For the oral message of course analyzed during the two years of research, the proportion of each level of knowledge was estimated to characterize these messages in connection with our hypothesis (Figure 4). In the oral statement of the Professor, the microscopic level is very few highlighted in the course which had already been mentioned by Gabel (1993). The symbolic level is far from dominant as had said Johnstone (1991) and Gabel(1993) According to our hypothesis, we see that a particular emphasis has been on the microscopic level for the course 'properties of certain substances', year 2% (16% to 38%) . Interestingly, we are also seeing an increase in the microscopic level for the other two courses, "physical transformation of matter" (12% to 26%) and "chemical equation" (6% to 10%) between the two years.

b. Achievements of students at the end of the course: The achievements of students in relation to the three levels of knowledge are presented horizontally for the three analyzed questionnaires.

Student responses were the subject of a quantitative analysis about their ability to identify the level of knowledge and establish links between two levels. Figure 5 shows the proportion of students who met the level of knowledge required in question and having established connections between two levels of knowing. For example, for the course reaction of some materials with solutions, he was asked to represent at the macroscopic level two experiences of implementation action on metals zinc hydrochloric acid and iron, to explain to the microscopic level highlighting the existence of Zn^{2+} , Fe^{2+} ions as well as to symbolically include the preparation of solution equations.

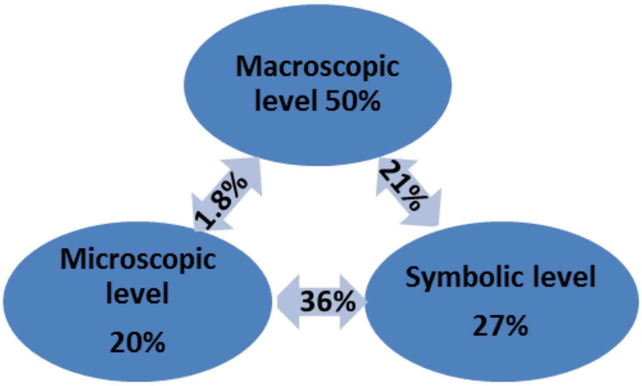

Figure 5: Proportion of students have complied with the level of knowledge required and having established links between two levels of information in their responses to the questionnaires

Slightly more than half of the students meet the macroscopic in their answers level while the symbolic level is respected by less than a third of students and the microscopic level is less than a quarter. Less than a third of students correctly link between two levels of information to explain a concept or a concept in Chemistry: dissolution, pressure of a gas, temperature of boiling and freezing of a solution... This quantitative analysis of questionnaires was clear that gaps in terms of identification of levels of and linkages between these levels exist for a large majority of students. The average to the questionnaire for all pupils was compared for each questionnaire between the first year and the second year (Figure 6).

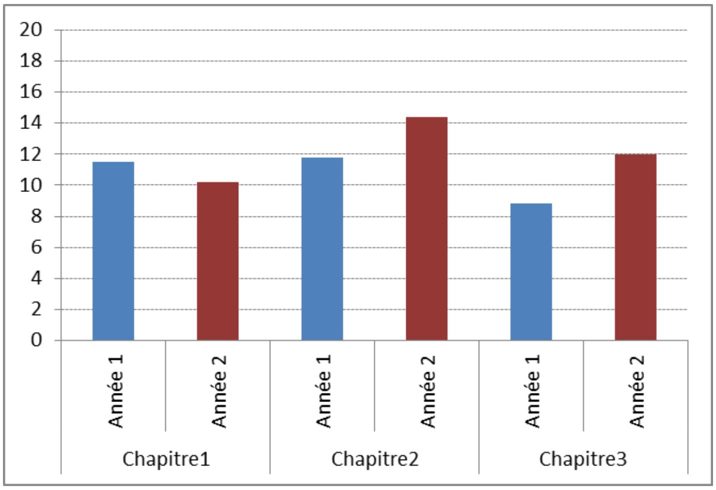

Figure 6. Comparison of means obtained in each questionnaire between year 1 and year 2 for two colleges

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

	Chapter 1		Chapter 2		Chapter 3	
Year	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
(Mean ± SD) / 20	11.5 ± 1.7	10.2 ± 1.6	11.8 ± 1.8	14.4 ± 1.6	8.8 ± 1.7	12 ± 1.5

Chapter 1: Physical transformation of matter

Chapter 2: Chemical reactions

Chapter 3: Properties of certain substances

For the "physical transformation of matter" questionnaire, students earn a significantly lower average the second year than the first, while for the other two questionnaires, 'Chemical Reactions' and 'properties of certain substances', students get a significantly higher than average second year **(table 2)**.

Conclusion

The contributions of this research are multiple and diverse and come in terms of:

- Creation of knowledge on chemistry in first course 2nd and 3RD year college;
- Creation of knowledge in the teaching of chemistry;
- Creation of knowledge for action to improve the educational communication in the course of chemistry;
- Professional development of participating teachers.

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