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Teacher-training: Analysis of teachers' representations about their impact on the teaching of the chemical reaction under the current system

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Abstract

We located our research within the teacher training framework of chemistry; one of the most important disciplines contributing to pupils' science training.
However, the current methods of teaching this discipline are not always effective and do not allow the teacher to teach the pupils appropriately.
In order to gain a deeper understanding of this situation and to gather information on the related limits and obstacles, we directed part of our research towards the system of teachers' representations about the teaching of the science.
We collected information from a sample of 24 of physics and chemistry teachers, who taught in secondary schools. We used the data gathered from a questionnaire sent to these teachers along with observations in certain situations.
In the light of this study, we identified two major hurdles, which were:
- the teachers had no confidence in the method of teaching science; and
-there was no thought given to learning when the method of teaching science was constructed.
To rectify this situation and achieve a more profitable outcome to teaching chemistry in the curriculum, it would be necessary to reflect upon and recast the didactic teaching methods.

Keywords: teaching, training, chemistry, scientific method.Introduction

INTRODUCTION

The teaching of chemistry is one of the most important disciplines contributing to the scientific training of students.

The objectives assigned to students focus on the learning of knowledge, demonstrations and the grasp of the scientific method. Therefore, it is based on the construction of scientific concepts, which are linked to the student's existing knowledge by representation and imagination.

The ability of the teacher is primarily to connect with students' minds in order to find an entry point into their cognitive processes.

However, current methods of teaching are not always effective and do not allow teachers to properly fulfill their objectives. Also, ''teachers often have difficulty understanding that their students do not understand because they have lost the memory of the path of knowledge, obstacles ...'' (Bachelard).

In order to gain a deeper insight and understand more closely the limitations and obstacles of the current method, we were interested in the teaching and learning process of the chemical reaction in the Moroccan secondary

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science education. The choice of this analysis was motivated by the fact that the chemistry lessons are among the most difficult to learn, considering the use of multiple concepts such as chemical element, substance.

In the Moroccan educational system, these courses were taught from the common core class to both science and technology students. Therefore, we directed a significant part of our research to analyzing the system of training physics and chemistry teachers on the teaching of the chemical reaction at this level.

Our goal throughout this study was not to limit ourselves to defining the difficulties encountered in teaching the subject, but, rather, we expected to contribute to the improvement of learning the subject.

1. THE RANGE OF TAUGHT COURSES ON CHEMICAL REACTION IN THE COMMON CORES OF SCIENCES AND TECHNOLOGY

One of the specific objectives of the curriculum of chemical transformations of matter in the common core is to establish a material balance. To do so, the chemical transformation of a system is associated with a chemical reaction, which reflects the evolution of the macroscopic system and results in a symbolic written equation.

When the kinetic evolution of the system is dealt with later, it will be necessary to develop a more elaborate model involving reaction intermediates and the corresponding equations. The model and its limitations are at the heart of this part.

The teaching guidelines specific to this knowledge are the following:

Contents	Examples of activities	Knowledge and expertise due
Chemical transformation of a system: * Modeling of transformation: -Examples of chemical changes -Initial-state and final state of a system. -Chemical reaction. -The equation of chemical reaction, reactants and products, the stoichiometric numbers.	-Characterization of chemical species present in the initial state (before processing system) and chemical species formed by means of simple experiments: - Copper foil in silver nitrate solution, - Iron powder in solution of copper sulphate, - Combustion of carbon, alkanes or alcohols in the air or oxygen, - Reaction of sodium and chlorine, - Synthesis reactions seen in the first part, -Precipitation of copper hydroxide ...	Describe a system and its evolution. Write the equation of chemical reaction with the stoichiometric numbers correct.
* Review material: -Introduction to the advancement of the reaction. Expression quantities of material of reactants and products during a chemical transformation. -Material balance.	-Experimental evidence of the influence of material quantities of reactants on the maximum progress and experimental verification of the validity of the proposed model of chemical reaction to describe the evolution of a chemical system undergoing a transformation: ethanoic acid on sodium hydrogen carbonate.	Understand the concept of "reaction progress" to calculate it.

2. PROBLEMS AND ASSUMPTIONS

The educational research shows that the quality of education plays a decisive role in determining an individual's scientific career. Any shortcomings at this level result in a misunderstanding of the new knowledge and cause imperfections, which affect negatively the quality of learning and the relationship of the learner with knowledge. Therefore, the failures, observed at the junior high school and high school stages, can persist and accompany students to the graduate level and become serious teaching obstacles.

Actually, the historical and epistemological study of chemical concepts can illuminate certain aspects of the evolving fields of reference and provide answers to empirical questions raised by past chemists. However, what about the question of teaching the chemical reaction effectively? How can teachers better accomplish their goals of reorganizing and enriching students' concepts of the subject matter, especially, in respect of their fundamental concept of the chemical reaction?

This situation raises two assumptions regarding the learning of the chemical reaction, namely:

- Physics teachers do not take into account the obstacles to students' learning of this concept; and
- The student does not participate in the construction of knowledge.

3. APPROACH AND METHODOLOGY OF RESEARCH

In order to achieve our objective, we adopted certain approaches and methods including:

- identifying affected populations and establishing the sample;
- developing the questionnaire and its administration; and
- shadowing classes.

3.1. Identification of populations of teachers and establishment of samples

In order to conduct our analysis, we went to the population of teachers. We selected a sample of 24 teachers practicing physical chemistry who were spread across 20 qualifying schools in Morocco.

3.2. Design and conduct of questionnaire

The focus was mainly on the opinions of the people concerned about the possible difficulties of high school students learning the chemical reaction.

Therefore, the survey of chosen teachers was structured around three parts which were taught in the course material to core science and technology students:

Part 1: The chemical changes of matter;

Part 2: The chemical reaction;

Part 3: The progress of a reaction.

For each part, teachers were asked to answer the following questions:

Question 1: Areas where there students show learning difficulties

Question 2: Cases that would cause such difficulties

3.3. Shadowing class:

This step allowed us to analyze the above strategies, used by the teachers in the classroom situation, to facilitate learning of the chemical reaction. After this phase, we analyzed the results.

4.ANALYSIS, DISCUSSION AND IMPLICATIONS OF STUDY RESULTS

4.1. ANALYSIS OF RESULTS OF THE STUDY

4.1.1. Analysis the rate of respondents and participants:

Initially, the first questionnaire was distributed to selected teachers. We had been agreed with the participants that they would have one to two weeks to complete and return it. This phase was marked by a very low rate of participation. Overall 6 out of 24 teachers responded, a rate of 25%.

In order to achieve a more significant participation rate, we opted for direct contact.

In this second phase, we opted to send the questionnaire to 20 teachers. Consequently, the response rate increased significantly to 83%.

Also, this phase was useful for conducting classroom observations.
We agreed with the volunteers on the schedules of their working sessions with students in classroom situations. We agreed six schedules involving six teachers in three different schools..

4.1.2 Analysis of questionnaire results:

Analysis of responses to two questions gave the following results:

Question 1: Where the students showed learning difficulties	Question 2: Causes of difficulties
- Balancing chemical reaction - Writing the symbols of chemical elements - The use of stoichiometric coefficients. -The use of the promotion list - Calculating the quantities of material processed and produced. - Distinction between chemical transformation and state change.	No assimilation of the concepts and the following: - Rules for calculating quantities of material; - Atomistic-concepts; - Mole; -Molar-mass; - Molar volume; and - Change of physical state is regarded as a change of chemical properties.

The majority of these teachers (18 out of 20) reported difficulties, especially in the writing of the equation and doing balance calculations during a chemical reaction. According to the teachers, these difficulties were caused by non- assimilation of the rules and the required concepts.

A minority (2 teachers) ascribed these difficulties to the students' confusion between the concept of chemical transformation and the change of physical state.

4.1.3. Results of observations in class status

Observations in class teaching situation of the chemical reaction yielded the following results:

- Generally, these teachers' approaches were similar;
- Definition of the chemical transformation;
- Modeling of transformation; and
- Balance of materials.

4.1.3.1. Definition of the concept of chemical transformation of matter

The vast majority of the volunteer teachers (5 out of 6) used the definition given in the textbooks, which was "transformation of matter in which the bodies disappear (reagents) and new bodies appear (the products)". The other teacher preferred a broader definition "alteration of the chemical properties of bodies."

Teachers, who preferred to emphasize the general definition, wanted to differentiate between the chemical transformation and change of physical state.

4.1.3.2. Teaching methods

All volunteers presented their lessons in a traditional way. No experiments were carried out; the majority of chemical transformations, dealt with, were combustions.

As justifications for their actions, they mentioned the time constraints, which added to an overloaded program, and the lack of the necessary equipments to perform the experiments.

These teachers evaluated their students' acquisition of knowledge throughout the sessions by oral questions and exercises.

4.2. DISCUSSION AND IMPLICATIONS OF THE STUDY RESULTS:

The results of our study require a few remarks about both the learning difficulties of the chemical reaction and the level of instruction in secondary schools in Morocco.

4.2.1. learning difficulties of the chemical reaction at the student level:

The majority of teachers reported difficulties in writing the balance equation and in making the calculations. Also, they gave the impression that the chemical reaction was similar to a mathematical exercise without any chemical significance. For this, we suggest that physics-chemistry professors focus more on educational research articles.

Various studies have highlighted six main types of problems hindering the learning of the concept of chemical reaction namely:

»Barriers to children's education

As part of daily life, teaching children about substances is governed by a set of restrictive rules, which limit not only contact with substances, but, also, the use of everyday language.

A large number of substances, used widely in everyday life, are not accessible easily by children. Chemicals for household use (drugs, insecticides, paints, glues, household products, etc.) are kept out of the reach of children. Moreover, this type of education prevents children from playing with fire, matches, kitchen appliances, etc...Although this attitude protects children from potential domestic accidents, it prevents them, also, from getting to know the various properties - or interactions - of substances.

»Barriers to the definitions of the concept

The concept of chemical reaction is a difficult concept to defining the microscopic and macroscopic level.

If the different definitions of this concept appear clear and complete, it is obvious that they refer to other scientific concepts, whose meanings are far from easy to identify, such as a substance, a new substance, radical substance, transformation, molecule, atom, ion, rearrangement, property.

These terms are the result of theoretical developments by research scientists in the field of empirical research and the practices of chemical laboratories. Consequently, a simple definition cannot ensure understanding all that represents the concept of chemical reaction. It requires the establishment of a field of empirical reference and requires development of questioning on a well chosen set of phenomena, which will promote the gradual creation of a suitable conceptual network.

»Barriers to the descriptions of the chemical reaction

Interestingly, the main description of the chemical reaction, which, has been identified, is the static aspect of the phenomenon without reference to its dynamic aspect. For many students, the difficulties are:

- Integrating the time factor (speed of reaction).
- Duality microscopic - macroscopic chemical equation working at the microscopic and macroscopic level. However, researchers have observed among students a lack of the concept of using chemical equation by going from the observable states (manipulative level) to modeled states (atomic level).
- Forward – reverse duality: the chemical reaction is often conceived and described in the forward direction and, rarely, in the opposite direction; this is because of the intensive use of total reactions such as combustion.

»Barriers to language:

The two types of language, involved in the construction of the concept of chemical reaction, are.

- The natural language: learning difficulties are due to interference with the vocabulary of everyday life; and
- The symbolic language: the first difficulty comes from the language of mathematics as students try to transfer from one domain to another, which could cause problems. The second difficulty stems from the distinction between microscopic and macroscopic significance of symbolic writing.

Researchers (M.Madrane M. Khaldi, R. Janati-Idrissi, R. Zerhane M. Talbi) underlined in their article on the review of RADISMA, [Spell out in full?], published in March 2007, that any teaching practice involved the use of speech supposed to convey a number of scientific concepts. This is especially true for disciplines such as biology, which represents a field of knowledge where little formal and symbolic representation is used, but, instead, there is a dominant verbal representation. Therefore, the vocabulary becomes a major tool for teaching different concepts. However, teachers' mastery of vocabulary and semantics of scientific concepts is far from being a skill acquired by all teachers. Consequently, barriers to learning can be generated by the speeches used by the teachers in conducting their teaching activities.

»Obstacles generated by books and textbooks

Textbooks and books are powerful vehicles of knowledge and represent major references for learners. However, formulations, presentation types and models, which are proposed to convey academic knowledge, could pose problems for readers. The result of these obstacles may impede easy assimilation of ideas conveyed by these references such as the type of models used and the juxtaposition of content generated through several issues in one chapter. The development of textbooks and the written translation of knowledge are difficult and involve a variety of skills (linguistic, disciplinary, pedagogical, didactic, semantic, etc.). We do not always find such skills among the authors of textbooks and academic books. The educational use of references is an important asset for teaching, provided they are used by the teacher to give a "reflective view". These tests are necessary to create conditions for proper use of these references.

»Barriers to representations that are related the learner

Studies, which have focused on the identification of chemical phenomena by students, showed that the representation of the concept of chemical reaction improved with time. Despite this progress, many students thought, when the phenomenon was a chemical reaction, there would be two reactants in the initial situation. Probably, students developed this concept because the majority of examples of chemical reactions, presented in textbooks for school, used two reagents. It was a failure in t its construction, which prevented and disrupted the functioning of the concept of chemical reaction.

In this regard, the study, done by LAUGIER and DUMON (2000), showed that when students were faced with a macroscopic phenomenology and had to imagine a microscopic explanation, they faced many obstacles. In order to identify them, these researchers' methodology followed two axes: one is didactic and another is historical.

The historical axis has identified families of obstacles along with the two registers: macroscopic and microscopic. According to the macroscopic register, the researchers presented the following three types of barriers:

- A substantialist obstacle: the properties of substances were considered as elements endowed with materiality.
- An obstacle of perception: the idea of disturbance phenomena, which hid a sensitive chemical transformation.

- A positivist obstacle: students considered that experience was that the only activity, which the chemist was allowed.

- According to the microscopic register, the researchers presented the following two types of obstacles:

- A mechanistic obstacle: students considered that the mechanical properties were trivial and had to be renounced.

- A realistic obstacle: students considered the need to describe reality only at the macroscopic level.

This historic axis led the researchers to conduct a study to identify learning difficulties for students during the construction of a representation of the concept of chemical reaction using the macroscopic and microscopy registers.

The main results of this study were:

- When students had to describe a process, which they believed to be chemical, barriers to the macroscopic phenomenology (substantialist and perceptive) occurred immediately. For example, for the reaction between nitric acid and copper metal, students attributed to a change in their reactive properties: acid turned blue, copper became liquid or roux turned into gas.

- Students had difficulties in using the microscopy register.

- The equation for the materialization of the students' difficulties in chemistry: each chemical transformation was reflected in a chemical equation, regarded by students as a mathematical exercise without any chemical significance.

- The chemical equation was not suitable for representing a chemical reaction performed in any proportions.

Other points of view on the difficulties of understanding the concept of chemical reaction have been developed. In his work, MEHEUT (1989) showed, even after instruction, middle school students did not understand the ratio between fuel and oxygen. It distinguished two types of student responses, which were:

- Answers which did not implement an invariant: students interested in the flame which had properties (it produced heat, transformed objects in its vicinity and the disappearance of matter).

- Answers to implementing an invariant: invariant mass (mass taken into account and that of the object but without taking into account the oxygen), and invariance of substances and non members (burnt wood was still wood, alcohol was burned, more alcohol and the resulting water were present in the fuel).

MEHEUT concluded that "the firings are not a good way to introduce the concept of chemical reaction." However, he proposed some directions for reflection and pedagogical interventions, which were:

* The burning of organic substances led to difficulties, it would be preferable to study the combustion of metals.

* The combustion involving gas are sources of difficulty.

* The flame and fire fascinate students; this prevents them from focusing on the chemical species actually involved in the reaction.

* There is confusion between combustion and change of state.

Moreover, STAVRIDOU and SOLOMONIDOU (1998) distinguished various stages during the construction of the concept of chemical reaction interacting with the appropriation of other concepts such as change of state dissolution.

The first stage is the phenomenology of the idea of change: the chemical reaction is an event. At this stage, some students did not consider the chemical reaction as a change but as an event with phenomenological demonstrations, for example: the color change. Other students considered these events as the reagents changing but ignored completely the final result of each transformation.

In the second stage there was a chemical reaction when two reagents gave something else, namely:

- The existence of two initial reactants: some students developed personal criteria for the identification of the chemical reaction. A phenomenon of chemical reaction occurred when two reactants were present in the initial state, and, therefore, they did not speak of the chemical reaction in the presence of a single reagent.

- New products that form: other students thought a chemical reaction was caused by the formation of a new product; they demonstrated the new product with the criteria of common sense, for example, the new product formed was just something different from the initial reactant.

The third stage was the relationship between phenomenology and structure of matter. The assimilation of some taught microscopic ideas appeared in the students' definitions of the concept of chemical reaction. The change of structure could be vague and could cover, as well as chemical reaction, several types of phenomena (inter, intra-molecular) and change of state. The students identified chemical phenomena fairly well and referred to their knowledge of everyday life as encountered in their laboratory knowledge. However, it did not apply to the result of a transformation in terms of formation of a new product. The concept of new product was fragile; it prevented the students to establish a connection between the concept of atomic level and the concept of manipulative level.

These studies have shown that during secondary education, students restructured their conceptual areas and built the concept of chemical reaction following a personal path. The progress of students was quite different from the expected increase in the curriculum.

4.2.2. Teaching of chemical reaction

By observations, which we conducted in the classrooms, we identified the definition, given by the majority of these teachers, for the chemical transformation as "transformation of matter in which the bodies disappear (reagents) and new bodies appear (products)". It did not distinguish between the chemical transformation of matter, and the change in physical state. However, students considered the changing physical state as a chemical transformation.

The challenge will be to make students understand that the chemical transformation is a process of reorganization of the atoms of the starting materials (reactants) to form new substances (products), during which the mass, the number and identity atoms are preserved.

The teachers adopted a lecturing approach, which was based mainly on the transmission of theoretical knowledge. The chemical reaction was given to the student as a series of rules to apply.

The teaching of chemical reaction in this manner is far from the scientific approach used in the experimental sciences.

The study by BARLET and PLOUIN (1994), on the chemical equation chemistry as a source of continuing difficulties, showed that some designs remained as a barrier to university entrance, due to misappropriation of concepts related to the chemical equation.

In order to promote the construction of the concept of substance (at the manipulative level), and to promote the expansion of students' categorical thinking of the students, which this construction implies, it is necessary to establish an empirical referent chemical and choose a number of tasks related to the intellectual empirical field.

The researches have chosen as a rule of thumb the following criteria:

1. Choose a variety of substances and interactions of a rich and varied phenomenology (simple mixing, dissolving, precipitation, color changes, gassing, or lack of sensible phenomena) in order to give students the opportunity to develop representations in manipulative terms, which are not possible in everyday life.

2. Organize the presentation of substances and their interactions in cycles of manipulation, a fact that corresponds to the successive empirical enlargements to which students refer.

3. Within each cycle of manipulation show that it can be something unknown rather than something that seems known to students. For example, in the first round of manipulation, we presented three pure substances looking the same - white, crystalline - to students, who had been interacting with each other in pairs. In all three cases, students observed different and, often unexpected, results, which made them think they were different and unknown substances.

4. Avoid introducing students to gaseous substances in the initial state, since many students at this level do not consider the gas as material bodies.

5. Avoid phenomena where heat and fire are involved, since it is known that the combustion pose multiple problems for young learners (Méheut 1982, Méheut and al. 1985, Solomonidou 1992).

From this empirical list, we have selected the following intellectual tasks for students:

- Observe and describe the materials presented.
- Search for commonalities and differences of certain substances.
- Predict the outcome of each manipulation.
- Observe and describe each manipulation.
- Compare the initial and final states.
- Detect and interpret the observed changes of matter.

The criteria for the selection of empirical referent and intellectual tasks are established in order to provoke students' reasoning and detach them gradually from the concrete and the known and move them into the realms of possibility and the unknown.

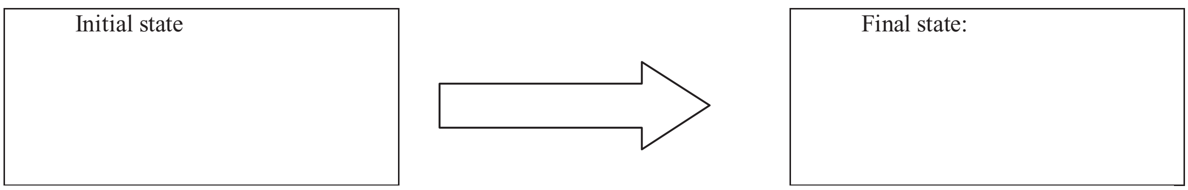
We propose the following experimental approach for modeling and studying the chemical transformations of matter:

1 - Description of the initial state:
Students should invent the chemical species to be mixed initially by reading labels and proper tests.

2 - Description of the final state:

-Formulation of hypotheses when the presence of species is expected to have the final state;
-Realization of experiments to confirm or disprove the hypotheses; and
-General conclusion.

3 - Schematic of the chemical transformation:



4- Writing the equation of the reaction.

5- Establishment of the progress chart that describes the evolution of chemical processing and experimental verification of the validity of the model.

CONCLUSION

The concept of chemical reaction is a fundamental pivot of the teaching of chemistry. The experts give several definitions for this concept, mainly the transformation of substances into other substances

If the definitions that were given are clear and simple in appearance, it is clear that their exact meaning is still far from being grasped easily by students. Similarly, it is noteworthy that in the daily lives of individuals, transformations of matter are understood using spontaneous categorizations (eg, natural or artificial) and common representations conveyed through everyday language (destruction, disappearance of matter, change or retention of the identity of substances, etc...). Therefore, students begin the teaching of chemistry with their own organizations and conceptions based on their personal experiences and education. The paradox, which should be clarified in this context, is to what extent the teaching of chemistry can succeed in its noble mission of reorganization and enrichment of the student concepts.

Therefore, if the teaching of chemistry does not help students to build the basic concepts; it would be difficult to achieve the desired results and students would not able to identify the chemical reactions of other phenomena as, for example, the physical transformation of matter.
Also, the current scientific concept of substances prevents students from making satisfactory connections between manipulative level (substance) entities and atomic level (molecule) entities. Therefore, the concept of substance is of crucial importance for teaching chemistry.

The analysis of current practices of using substances as part of daily life has identified a number of representations on common substances and their interactions (materials treated as objects, regarded as inert, etc...). This analysis, together with the fact that substances in everyday life are extremely complex, have strengthened the hypothesis that children find it almost impossible as part of their everyday life to build the concept of substance. Consequently, teachers of chemistry have to accomplish this task.

The construction of scientific concepts of substance and chemical reaction should occur in the pedagogical context of teaching chemistry and adapting and extending research. The teaching mission is to explore the phenomenology of the transformations of matter and must develop phenomenological criteria to help students identify and differentiate between substances and to categorize their transformations.

In a second step, this teaching should clarify the boundaries of these criteria and address the need to establish scientific criteria rather than allow students to identify the substances and understand their transformations. In this context, teaching practice is extremely important. The construction of the concept of substance, at the manipulative level, should precede modeling at the atomic level. Therefore, this construction would facilitate the transition towards a process of articulation between different representations both at the manipulative and atomic levels.

Also, the teaching of chemistry should address the obstacles arising everyday language and act on the thoughts conveyed, as far as chemicals are concerned. Consequently, students will be considered to be true actors and will participate in all processes; such as the laboratory experiments, which affect them and, at the same time, foster effective learning by facing their difficulties. .

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