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

The Student's Conceptions about the Nuclear Fission and Fusion

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Date of publication (dd/mm/yyyy): 12/07/2017

***Abstract* – In recent decades, nuclear fusion and nuclear fission becomes a very useful source for the production of electrical energy. In this work, we propose to study the importance of the conceptions of the Moroccan high school students about the nuclear fusion and the nuclear fission during their learning.**

***Keywords* – Fusion Energy, Nuclear Fission, Student's Conceptions, Thermonuclear Fusion.**

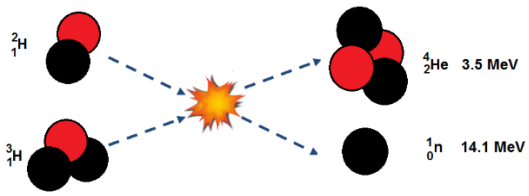
I. INTRODUCTION

For thousands of years, the sun emits light and heat on our earth so that life is possible. Every second, it transforms 600 million tons of hydrogen into helium, releasing a large quantity of energy. Nuclear fusion is the physical reaction that takes place in the centre of the sun releases this energy. The high temperature of the sun (about 15 million degrees in the center of the Sun) allows hydrogen nuclei to collide at very high speeds. This gives the possibility of crossing the barrier which the electrostatic forces create between the positive electric charges borne by the hydrogen nuclei. Thus, the fusion of two nuclei of hydrogen gives birth to a new nucleus of helium. The mass of the helium atom obtained does not correspond exactly to the sum of the masses of the two starting atoms. Some of the mass has disappeared and a large quantity of energy has appeared. This phenomenon is expressed by the Einstein's famous equivalence mass-energy.

The importance of the quantity of energy released by the sun has motivated the scientific community to find ways to exploit fusion as a new source of sustainable energy [1-3], since the necessary raw materials are virtually unlimited.
In the 20th century, the science of nuclear fusion identified the most effective fusion reaction in the laboratory. It is a reaction between two isotopes of hydrogen H: deuterium (D) and tritium (T). The D-T fusion reaction is the one that achieves the highest energy gain at the "lowest" temperatures.

Currently, the International Thermonuclear Experimental Reactor (ITER) is an international scientific project of nuclear fusion experimental reactor based on the principle of magnetic confinement. This project is used to reproduce thermonuclear reactions on Earth virtually similar to those that take place in the stars.

On the other hand, since 1950, the production of electricity became possible in the United States because of another induced nuclear reaction, known as nuclear fission. The phenomenon of spontaneous fission was discovered in 1940 by GN Flerov and KA Petrzak working on nuclei of Uranium 238. Generally, nuclear fission consists of breaking heavy atomic nuclei, such as those of uranium 235 or plutonium 239. Projecting on them a neutron. A heavy nucleus, struck by a neutron, is divided into two lighter atoms. This reaction releases energy and neutrons that can strike other heavy atoms that divide in turn. Induced fission releases significant energy [4], noting that one gram of uranium 235 releases as much energy as the combustion of several tons of coal. The neutrons released by fission have a very high energy. If they can be slowed down properly in nuclear reactors, they can induce new fissions and the reaction continues and accelerates. But if one allows to increase the number of neutrons present, the reaction can become explosive, it is the case of the atomic bomb. Nowadays, few teachers take into account the initial representations of the students during their lessons, which explain that the learner acquires only an illusion of the knowledge and this one glides over the surface. The student's conceptions remain then active and can even strengthen.



Recently, several authors have study the nuclear fission [5-7] and the thermonuclear fusion [8-11]. S. J.Zinkle and J. T.Busby report on the Structural materials for fission and fusion energy [12]. G. Tsaparlis, S. Hartzavalos and C. Nakiboglu report on Students' Knowledge of Nuclear Science and Its connection with civic scientific literacy in two european contexts [13]. However, we propose to study the importance of the conceptions of the Moroccan high school students about the nuclear fusion and the nuclear fission during their learning.

The aims of this paper is to identify the different types of students' conceptions from the second year of high school, section physical chemistry, nuclear physics (phenomena of nuclear fission and fusion), which allow us to improve the quality of education to ensure that the students could have a more elaborate scientific knowledge.

The second section provides the research methodology, the population studied and the questions concerning our subject. In the last, we comment the results obtained from our study.

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II. Research Context and Methodology

A. Working Approach

The research methodology consists in the collection of data by using multiple-choice questions including open-ended questions.

We therefore think that the fact of using this type of questionnaire will give us more relevant information on how the learners' conceptions are structured. The teacher will then classify and use them easily in order to provide the best possible education for learners.

B. Population Studied

This research aims to identify the different types of students' conceptions from the second year of high school, section physical chemistry, nuclear physics (phenomena of nuclear fission and fusion), which allow us to improve the quality of education to ensure that the students could have a more elaborate scientific knowledge. So, we took a sample of 100 students from three different schools in the region of Casablanca. The table below sets out the high schools chosen for this research and the number of students:

Table 1: Number of students and high schools selected for the research

High schools	**Number of students**
High school Abdelkrim LAHLO (Casablanca Anfa)	38
High school Abou Bakr SEDDI (Mohammedia)	33
High school le CEDRE (Casablanca Anfa)	29
Total	100

C. Questionnaire

Our research is focused on the phenomena of nuclear fission and fusion, we developed 13 questions concerning our subject of study. We have used all of them to develop our questionnaire (Appendix 1).

Here then, thirteen (13) questions with their answers, as presented in the questionnaire:

Table 2: Questionnaire with answer

Question	Correct answer
1) 1/ What is the difference between nuclear fission and fusion?	… … … … … … … … … …
2/ Is the nuclear fission reaction : Spontaneous or Induced	Induced
2) 3/ The nuclear fission occurs in nuclei : Light or Heavy	Heavy
3) 4/ How is called neutrons that cause the nuclear fission reaction : Fast neutrons or Light neutrons	Fast neutrons
4) 5/ The nuclear fusion is a reaction: Mechanical or Kinetics or Thermal	Thermal
5) 6/ What are the conditions to trigger reactions of nuclear fission and fusion?	Very high temperature
6) 7/ What the reaction of nuclear fusion produce : A nucleus heavier than the nuclei of reagents A nucleus lighter than the nuclei of reagents	A nucleus heavier than the nuclei of reagents
7) 8/ The hydrogen bomb is due to a reaction of: Nuclear fusion or Nuclear fission	Nuclear fusion
8) 9/ Today, what is the most used reaction in diverse nuclear applications : Nuclear fusion or Nuclear fission	Nuclear fission
9) 10/ What is the nuclear fuel used in nuclear fission : Uranium or Silicon	Uranium
11/ What is the nuclear reaction that occurs in the sun?	Nuclear fusion
12/ The fission of 1 gram of uranium produces energy E1, and the fusion of 1 gram of deuterium produces energy E2. Is? E2 = E1 or E2 < E1 or E2 > E1	E1 < E2
13/ What are the applications of nuclear fission and fusion?	Production of energy. Medical, Industrial and military application

III. Results and Discussion

D. Results

We classified the responses of students in three categories: Category of correct answers, wrong answers and absence of response. The Table 3 shows the results of the questionnaire according to the frequency of occurrence of each category.

Table 3: Results of student responses to the questionnaire

N° of Question	Correct answers	Wrong answers	Absence of response
Question 1	44 %	26 %	30 %
Question 2	27 %	65 %	8 %
Question 3	85 %	11 %	4 %
Question 4	49 %	37 %	14 %
Question 5	49 %	44 %	7 %
Question 6	6 %	29 %	65 %
Question 7	75 %	17 %	8 %
Question 8	40 %	46 %	14 %
Question 9	57 %	25 %	18 %
Question 10	81 %	12 %	7 %
Question 11	15 %	27 %	58 %
Question 12	30 %	51 %	19 %
Question 13	14 %	12 %	74 %

Thus, to analyze the results of the questionnaire responses, we have established, in Fig.1, a comparison histogram of questionnaire responses according to the frequency of occurrence of each category.

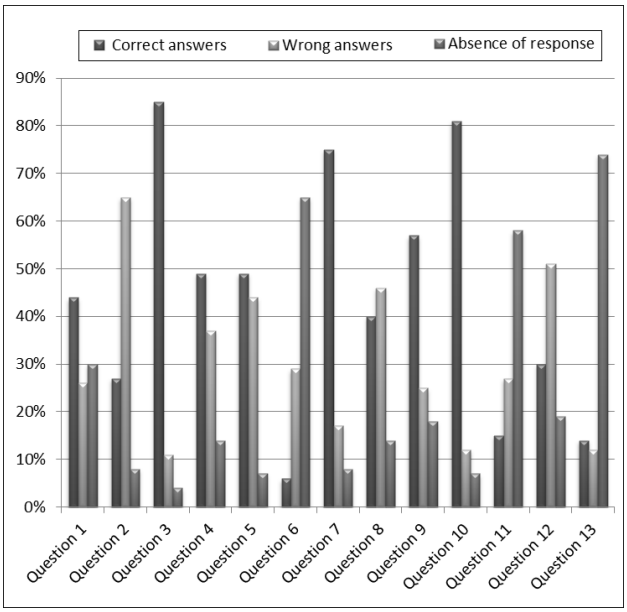

Fig. 1. Comparison histogram of questionnaire responses according to the frequency of occurrence of each category.

E. Discussion

The results of the answers to question 1 show that the rate of correct answers is 44% against 56% for all the wrong answers and without answer, this means that half of the questioned students do not focus on the difference between nuclear fission and fusion. We notice that 65 % of the answers of the question 2 are wrong what shows that the majority of the students think that the reaction of the nuclear fission is spontaneous, perhaps it is due to the confusion with the radioactivity which is a spontaneous phenomenon. For question 3, the majority of students (85%) have correct answers, and assert that nuclear fission occurs in heavy nuclei. We notice that half of the students assert that the fast neutrons cause the nuclear fission while the other half think that they are the light neutrons. The students confuse the term light nuclei (produced by the nuclear fission) with the term light neutrons. We notice that 49 % of the students assert that the nuclear fusion is a thermal reaction, on the other hand 44 % think that it is a kinetic or mechanical reaction. The students link the term fast neutrons (which cause the nuclear fission) to the kinetic term, which produces consequently, false answers. We notice that the majority of the students (65 %) deny the triggering conditions of the nuclear fission and fusion. According to the results of the question 7, we can notice that the majority of the students (75 %) had correct answers, and agreed on the fact that the nuclear fusion produces a nucleus heavier than the nuclei reagents. We notice that 46 % of the students had false answers and think that the hydrogen bomb (H-bomb) is due to a nuclear fission reaction against 40 % of the correct answers. The students link directly the term of nuclear bomb to the phenomenon of the nuclear fission. We notice that more than half of students (57 %) assert that the reaction the most used practically is the nuclear fission, 25 % of the students had false answers, this rate of wrong answers should not be neglected. A very important percentage of the correct answers (81 %) reflects the good knowledge of the students about the fuel used in the nuclear fission against a low percentage (12 %) of false answers. The rate of the absence of the answers is very high (58 %), which indicates that the students deny what occurs at the heart of the sun. We also notice that 27 % of the students had false answers and think that at the heart of the sun occurs a nuclear fission. According to the question 12 we notice that half of the students had false answers and think that the energy produced by the nuclear fusion is more important than that produced by the nuclear fission, against 30 % of correct answers and 19 % of absence of answer. The absence of response for the question 13 reached 74 % indicating that the students deny absolutely the applications of the nuclear fission and fusion.

These obstacles will be in parallel with the type of obstacle (classification of Bachelard) and the knowledge expected and will be summarized in the Table 4:

Table 4: classification of the obstacle and the expected knowledge

Obstacle	Type of obstacle	Knowledge expected
During the nuclear fission, the heavy nucleus becomes a lighter nucleus. So during the nuclear fusion, the light nucleus becomes a heavier nucleus.	Verbal obstacle : The students use the term « becomes » instead of the terms « divides » or « is assembled ».	- The nuclear fission is an induced process where a heavy nucleus is divided into lighter nuclei by bombarding it with a neutron. - The nuclear fusion is an induced process where two light nuclei are assembled to form a heavier nucleus.
The nuclear fission is a spontaneous reaction.	Obstacle of the general knowledge: confusion with the radioactivity which is a spontaneous phenomenon.	Nuclear fission is an induced reaction after a bombardment by a fast neutron.
The light neutrons cause the reaction of the nuclear fission.	Obstacle of the general knowledge: Students confuse the term light nuclei (product of nuclear fission) with the term light neutrons.	The fast neutrons cause the reaction of the nuclear fission.
The nuclear fusion is a kinetic reaction.	Obstacle of the general knowledge: the students link the term fast neutrons (which cause the nuclear fission) to the kinetic term.	The nuclear fusion is a thermonuclear reaction.
Non-knowledge of the triggering conditions of the nuclear fission and fusion.	Obstacle of the general knowledge.	Very high temperature.
The hydrogen bomb (H-bomb) is due to a nuclear fission reaction.	Obstacle of the first experience: The students link directly the term nuclear bomb to the phenomenon of nuclear fission and neglect the fact that nuclear fusion has been used in the hydrogen bomb.	The hydrogen bomb (H-bomb) is due to a nuclear fusion reaction.
Non-knowledge of the nuclear reaction which occurs in the sun.	Obstacle of the general knowledge.	The nuclear reaction which occurs in the sun is a nuclear fusion reaction.
The energy produced by the nuclear fusion is more important than that produced by the nuclear fission.	Obstacle of the first experience	The nuclear fission produces energy more important than that produced by the nuclear fusion.
Non-knowledge of the applications of the nuclear fission and fusion.	Obstacle of the general knowledge.	- Production of energy. Medical, industrial and military application.

F. Proposed Solutions

The collection, the analysis of the students' conceptions and the definition of the knowledge to be acquired according to the revealed obstacles served us for developing solutions while including the methods evoked by the researchers to overcome the observed obstacles.

We suggest realizing a didactic situation centered on the crossing of identified obstacles, according to the concept objective-obstacle of Jean-Louis Martinand and the following process of implementation of Astolfi:

- Choose one or several passable obstacles for the sequence.
- Settle for objective the crossing of these obstacles, which will establish an intellectual progress for the students.
- Build devices to reach the objective, as well as the remediation procedures in case of difficulties.

During this approach, we also suggest using the modelling and the simulation. We can develop the learners' conceptions towards a more scientific knowledge, by making certain scientific concepts more accessible. Indeed, the nuclear fission and fusion are substitute phenomena of the reality because they are too complex and inaccessible in the direct experimentation.

The role of socio-cognitive conflict has also been widely praised by Doise and Mugny that is why we suggest establishing in the class moments of debates to develop certain representations.

In this sequence, it is necessary to make the students active in the construction of their knowledge, by conferring to them great opportunities to speak, to debate, so that the representations are in confrontation as often as possible to destabilize them. We also suggest establishing

at the end of every session reminders by the students of all what they learnt during this one, in order to try to register durably the learnings.

IV. Conclusion

Our researches demonstrated that the fact of taking into account the representations of the students can teach us a lot about their way of thinking, as well as the way to reach scientific knowledge.

The teacher can so lean on these representations and on the obstacles revealed to schedule his learnings, moreover some researchers preach the method "objectives obstacles", to help overcoming them through educational devices. For our part, we think that making the student actor of his learning by conferring him autonomy, and by giving him the ways to modify his models of thoughts by destabilizing his representations with numerous confrontations, can also help to modify them.

In our view, make them aware of their own representations compared with those of others, should be a beginning, and confront their conceptions to develop them durably has to be a constant objective for the teacher.

Several authors dealt with the question of the initial conceptions and the crossing of their obstacles, and agree on the fact that there is no universal method for overcoming the obstacles. Indeed, given the plurality of the obstacles, they do not require the same conceptual changes as well as a different didactic treatment. However the teacher has to envisage several methods to help the students overcome these obstacles.

The researches in didactics opened the way to a new era for the history of education. For a significant educational advance, the question of the representations must be studied in a deeper way during the training of the professors, and the teachers should from today integrate the representations into their educational approach, in order to provide means for the students to evolve in function of their preconceptions, to really put the student at the heart of the educational system.

Acknowledgment

This work was supported by regional center for the professions of education and training, Casablanca- Settat and by laboratory of Condensed Matter Physics, Faculty of Science Ben M'Sik. Author thanks A. Hanioui, E. Hrida and L. Haloui for effort and cooperation to complet this work.

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