View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Directory of Open Access Journals

European Journal of Educational Research
Volume 8, Issue 2, 567 - 579.
ISSN: 2165-8714
http://www.eu-jer.com/

The Impact of an Interactive Approach on the Evolution of Moroccan University Students' Conceptions of Neurotransmission

Ihsane Kouchou*
Sidi Mohamed Ben Abdellah University,
MOROCCO

Fatiha Kaddari
Sidi Mohamed Ben Abdellah University,
MOROCCO

Nezha Bennis
Sidi Mohamed Ben Abdellah University,
MOROCCO

Abdelrhani Elachqar
Sidi Mohamed Ben Abdellah University,
MOROCCO

Received: March 10, 2019▪ Revised: April 3, 2019▪ Accepted: April 10, 2019

Abstract: Currently, it is taken for granted that teachers have to take into account the conceptions in order to achieve some efficient learning, the latter are generally resistant and may hinder the learning. Studies have shown that learning amounts to make conceptions evolve which play a determining role in the appropriation of scientific concepts such as neurotransmission, which is the subject of our study. This concept is present in the Life Science syllabus as early as high school. The aim of this study is to assess the impact of an interactive approach on the evolution of students' conceptions of neurotransmission. For this purpose, a questionnaire was administered to the first two years' students (second year) in the Life Sciences stream at Dhar El Mahraz Faculty of Science in Fez during the academic year 2016-2017. This questionnaire was in the form of a pre-test and a post-test on learning/teaching of neurotransmission. The results of the study showed that the approach which was adopted had a positive effect on the evolution of the students' conceptions of neurotransmission in that it apparently contributed to a conceptual change for them.

Keywords: *Initial conceptions, neurotransmission, interactive approach, conceptual change, evolution.*

To cite this article: Kouchou, I., Kaddari, F., Bennis, N., & Elachqar, A. (2019). The impact of an interactive approach on the evolution of Moroccan university students' conceptions of neurotransmission. *European Journal of Educational Research*, *8*(2), 567-579.doi: 10.12973/eu-jer.8.2.567

Introduction

Although pedagogical innovation is in vogue, the masterful method that is the subject of various criticisms (Bireaud, 1990) remains the main mode of knowledge communication in higher education (Bouchard & Parpette, 2007). In fact, these innovations insist to foster new forms of learning and new teaching methods based on student-centered approaches which focus on the student and what he learns (Bertrand, 2014). Indeed, it shows that the traditional pedagogical model based on the linear transmission of knowledge is becoming increasingly inadequate and unsuited to the new training issues and the nature of the current student population (Felouzis, 2003). However, this masterful method is essential in pedagogical contexts that know a massification in the higher education, such as Morocco. Indeed, it relies on transmissive teaching where the student tends to remain passive and not engaged in the processes of reflection and construction of his knowledge (Kaddari, 2005).

Through this work, we aim to measure the knowledge learned by students after adopting an interactive approach in the teaching/learning of neurotransmission at university. In this sense, the question is what are the tools and pedagogical strategies that the teachers must adopt in order to make these students more interactive and bring them to be involved in the learning process.

The interest was focused, more particularly, on a neurophysiology course articulated around neurotransmission, which is a fundamental concept in biology that allows to be located in the neuroscience field (Glickstein, 2006), representing today the tip of the scientific research.

Neuroscience, which appeared in the middle of the 20th century, brings together the scientific disciplines whose research aims to understand the nervous system and its functioning (Clarac & Ternaux, 2008).This area of investigation is expanding every day, to give birth to a new discipline called "cognitive neuroscience" that focuses on the neurological bases of functions such as language, learning, reasoning, etc. The intersection between neuroscience and education sciences has given rise to many current debates. In fact, neuroscience taken in a broader context, can allow

***Corresponding author:**
Ihsane Kouchou, Faculty of Science, Sidi Mohamed Ben Abdellah University, B.P. 1796, Fez-Atlas 30000, Morocco.
✉ kouchouihsane88@gmail.com

understanding of the learning phenomena (Doudin & Tardif, 2016). However, neuroscience, as all other scientific disciplines, does not escape complexity, and the understanding of cerebral phenomena will progress only through a constructivist approach (Clarac & Ternaux, 2008).

Neurotransmission is an exciting crossroads and represents a crucial moment in the history of biology. It is first and foremost a major mode of cellular communication and a key in understanding the language of cells (Dupont, 1999). Neurotransmission refers to the passage of a nervous message across a synapse through the discharge of a neurotransmitter stored in pre-synaptic vesicles released from the pre-synaptic surface into the synaptic cleft and its fixation by specific receptors present on the post-synaptic surface (Loewi, 1935).

In the Moroccan context, this concept is introduced in High School through a didactic transposition adapted to the cognitive level of pupils, and its teaching continues at university according to an appropriate didactic and pedagogical progression. However, in an earlier study of student conceptions, this content seems unattractive and uninteresting to students. It has been found that, in principle, students' conceptions of basic concepts are unchangeable and do not evolve despite intense learning at university. It was also noted that the results of the summative evaluations are still unsatisfactory and below expectations.

On this basis, we hypothesized that the adoption of an active pedagogical approach in the Teaching/Learning of the neurotransmission concept may contribute to developing conceptions of students and induce a conceptual change in order to build their scientific knowledge.

Conceptual Framework

As mentioned above, in this research it was tried to revitalize the lecture through an interactive pedagogical approach. For this, the researchers relied on two main criteria which are the basis for effective learning:

- The consideration of previous conceptions of the learner. Indeed, the latter arrives in the classroom with conceptions more or less in line with scientific reality and which can hinder his learning (Giordan, 1994).
- The motivation of the learner which allows him to find himself in the proposed context, to gauge his own knowledge and skills (Viau, 1994). Indeed, Houssaye (1993), defined as ''any intervention that leads the learner to express himself, which allows him to take care of himself freely, promotes his personal growth and helps to increase his motivation for success''.

Conceptions

Researches in science didactics are unanimous on the fundamental role of conceptions for organizing the learning situations of scientific concepts. Jean 'Migne (1994) was one of the first to introduce the notion of conception into didactics. The definitions attributed to this notion "conceptions"; even if they are multiple, all converge towards the knowledge of the learner. Thus, for Paccaud (1991), conceptions are "what we have left when we have forgotten everything", for Astolfi and Peterfalvi (1993) a student's conceptions function as "a system of interpretation of the scientific situations encountered". As for Giordan (1996), he defines conception as "the fruit of a previous experience of the learner".

Taking into Account of Conceptions in Learning

The pupil does not come to class as a blank page but with already established ideas and knowledge, as wrote Bachelard, in1938. These prior conceptions have an importance in later learning because they can promote learning or block it when they do not evolve (Ozmen, 2004), that being why a better account of these conceptions in lessons would be beneficial from the perspective of the effectiveness of learning. Indeed, several researchers are agreeing that the failure to take learners' conceptions into account can lead the teaching run into a number of obstacles (Viennot, 1988; DeVecchi, 1992; Giordan, 1994; Giordan, 1998; Soudani, 1998; Kaddari, 2005; Kochkar, 2007; Laribi et al., 2010; El Hassouny, 2014; Sadi, 2014; Bouayad, 2015; Schneider & Stern, 2010; Abraham, Perez & Price, 2014; Kampourakis, Silveira & Strasser, 2016).

The Conceptual Change

All learning achieved by the learner implies a sustainable transformation of its conceptions "conceptual change" which was designated by Joshua and Dupin (1999) as the passage of a conception from a primitive to a more advanced state and more abstract. For DiSessa (2002), it consists in moving from fragmented knowledge to a well-structured knowledge, and for Vosniadou (2002), it is an assimilation of new knowledge to the existing structures. As for Duit (1999), it is the evolution of learners' initial conceptions towards more reflective or closer to those from the scientists, or both at the same time.

In this respect, several pedagogical strategies such as Hewson and Thorley (1989), Vosniadou and Ioannides (1998), Hewson, Beeth and Thorley (1998) and Macbeth (2000), are taken as models to promote conceptual change.

Indeed, according to the model of Hewson and Thorley (1989), the original conception, which is initially relevant, gradually loses its status and is replaced by another conception close to that of scientists. Within this framework, the teaching intervention recommended for the teacher mainly consists in creating a cognitive conflict at learning, which causes dissatisfaction on their premises and thereafter the remainder of the process of conceptual change is carried out naturally. Thus, for the second model of Hewson, Beeth and Thorley (1998), the teacher must encourage the expression of a variety of ideas from a group of learners in the class, and he must also invite them to explain their ideas through discussion which is also a strategy that encourages conceptual change (Driver, 1989).

Method

The first step of this work consisted of the determination of the neurotransmission content in the knowledge taught at university level. For this, we used the curriculum and course materials written by the teachers. This showed us how the concept is defined and presented. Indeed, the neurotransmission concept is treated in the course of physiology of the nerve and muscle cells, through the functional anatomy of the neuromuscular junction or neuromuscular synapse at the base of the motor command. In this study, we focused on the following concepts: neuron, synapse, neurotransmitter and neurotransmission.

Thereafter, we examined the syllabus content of the high school curriculum dealing with neurotransmission or synaptic transmission. For this, we relied on "life and earth science" school textbook used in the first year of baccalaureate pupils, where this subject is treated. This review allowed us to identify the basics of this concept and, therefore, have an insight into the level of the concept formulation in high school and the estimated conceptual profile among students at the beginning of the university curriculum.

Subsequently we developed a questionnaire as a diagnostic tool articulated around the basic fundamental notions of neurotransmission. The questionnaire was administered to students:

- Upstream of neurotransmission teaching for a determined student population, in order to have an idea about the knowledge and the prerequisites of the students about the concept before the beginning of their neurotransmission learning at university.

- Downstream of this course for the same population already surveyed, in order to evaluate the impact of an interactive approach on the evolution of these students' conceptions. It should be noted that we adopted this approach in the lecture and practical work sessions.

Descriptive of the Adopted Interactive Approach

Inspired by the Hewson and Thorley (1989) and Hewson, Beeth and Thorley (1998) models, previously described in the conceptual framework as models to promote conceptual change among students, we have adopted an interactive approach based on a strategy of taking into consideration the initial conceptions of students and then on questioning and investigation which are fundamental in the construction of an adequate knowledge close to the scientific reality one. It should be noted that this interactive approach was adopting during the lecture session and even in the practical session of work.

Indeed, the adopted instruction consists of a new presentation of the lecture course by introducing relevant and pertinent questions by the teacher during the learning process to stimulate students' cognition without making them physically active in order to find responses and solutions for the proposed situations. We had tried to create a cognitive conflict among students which can cause dissatisfaction through their initial conceptions about neurotransmission concept. This dissatisfaction stimulates the conceptual change process among these students who are becoming more engaged and motivated to learn and contributes to an effective learning.

A part of the session was devoted to discussion and scientific debate to invite students to express their conceptions and ideas in order to create an interactive atmosphere between them and teacher. Also, students were brought to answer an evaluation test to involve them more in their learning and to build a coherent knowledge.

The lecture course has been enriched by explanatory diagrams to facilitate the learning process and help the memorization of scientific concepts by students.

In the practical work session of neurotransmission, the teacher used filmed sequences, videos and even the Internet sites in order to better visualizing the studied concepts and capture the students attention. In this session students are invited to practice the experiment with their pairs to be more engaged in their learning.

Description of the Questionnaire

To better understand the conceptions of the students surveyed, we have diversified the types of questions: Closed-ended questions, open-ended questions and schema requests:

- Six closed-ended questions (Q1, Q2, Q3, Q4, Q5 and Q7) in the form of multiple-choice questions, which the students surveyed, choose the appropriate answer proposed. These multiple-choice questions limit the type of answers and facilitate their treatments.
- Two questions for students to draw the schemas of both concepts (synapse (Q6) and neuron (Q8)).

- Two open-ended questions (Q9 and Q10) were used. Since the students surveyed are free to answer as they wish, it allows to get a closer view at what students think exactly and to collect a wide variety of answers, including the ones we did not expect.

This choice of multiple types of questions was to check the implication of the subjects questioned and, thus, the validity of the questionnaire and the coherence of the answers.

Sampling and Conditions of Administrating the Questionnaire

The questionnaire was administered to 120 second-year, (semester-4) students of the Life Science major at Dhar El Mahraz Faculty of Science during the 2016-2017 academic year. As already mentioned, the questionnaire was administered twice: Upstream and downstream of neurotransmission learning. We first gave out the questionnaire to students in an amphitheater before they started learning about the concept as a pre-test.

Then, after a month and half of learning the concept, we repeated the questionnaire in an amphitheater for the same population.

In both cases the students took 30 to 45 minutes to complete the questionnaire. We also told them that the questionnaire is anonymous, and that it is not evaluated.

Treatment of Results

- The results of the collected data for the closed questions have been processed by Microsoft Excel Software 2007.

- For the open-ended questions (Q9) and (Q10), the analysis was based on the key words of each concept definition given by students and using Microsoft Excel Software 2007 for the results treatment.

Data were submitted to ANOVA analysis for each sampling in order to determine significant differences between the means and to find out if the experiment results are significant. Basically, we're testing the evolution of students conceptions between the pre-test and post-test to see if there is a significant difference between them and to visualize the impact of the adopted interactive approach on the progression of students conceptions about neurotransmission concept. A multiple range test at the 95% confidence level was performed using Tuckey's method. It should be noted that the correct answers were coded by (True) and incorrect answers by (False). The statistical processing of the data was carried out with the software XLSTAT 2014 that uses Microsoft Excel Software for inputting data and displaying results.

Results

In Question 1 (Q1), which focuses on the propagation of nervous message, the data obtained (Fig.1) showed that, upstream of the neurotransmission teaching, 72% of students opted for the incorrect proposition which says that the nervous message propagates continuously while 28% say that it propagates in a discontinuous manner. Downstream of this teaching with an interactive approach, we note an increase in the percentage of correct students' responses that reaches 63%.

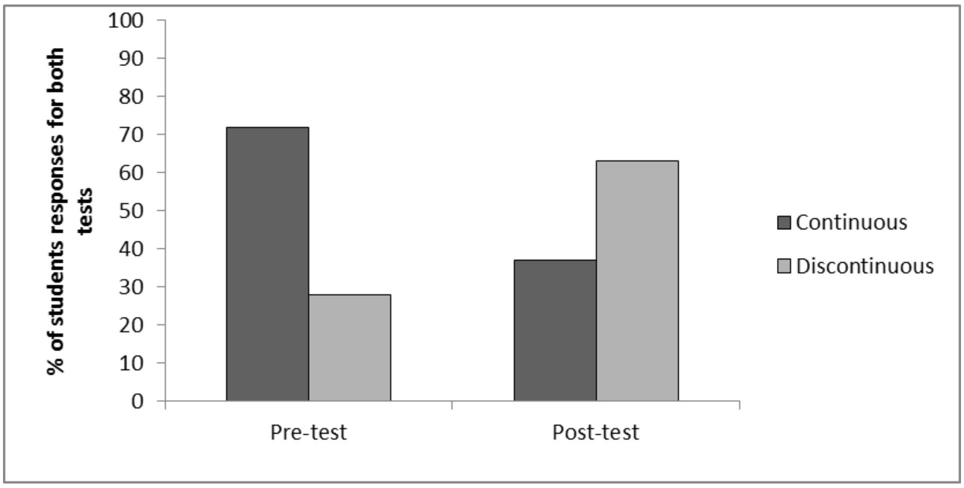

Figure 1. Percentages of Responses: Propagation of nervous message.

The second Question 2 (Q2) focused on the nature of the nervous message (Fig.2): Upstream of this teaching, only 23% of students opted for the correct proposition stating that the nervous message is both electrical and chemical.

This finding seems to be improved downstream of the teaching of neurotransmission since 76% of the students were able to give the correct answer of the nature of the nervous message (electrical and chemical nature).

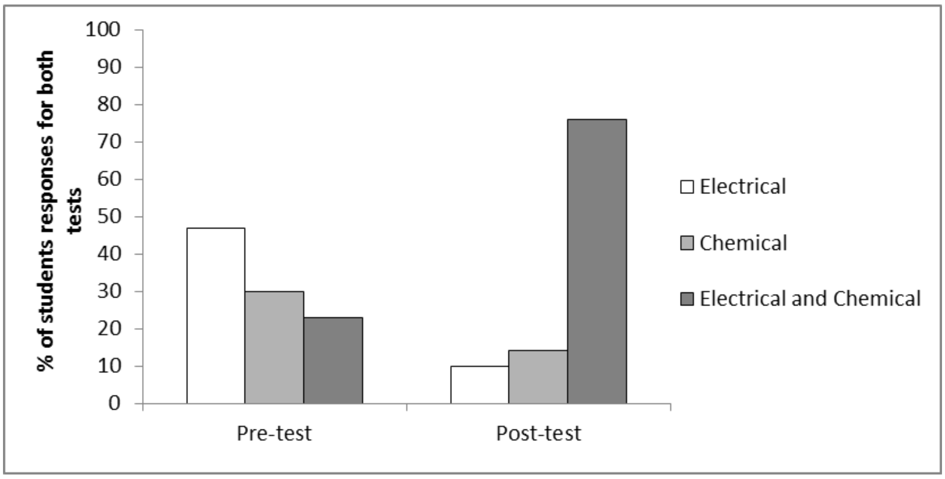

Figure 2. Percentages of Responses: The Nature of the nervous message.

The question (Q3) aims to determine the structure responsible for the transmission of nervous message (neuron, synapse or axon). Student responses (Fig. 3) showed that upstream of this teaching, 68% of them opted for the correct proposition with knowing that the synapse is the structure responsible for the transmission of nervous message. As for the 32% of the remaining students, they opted for incorrect answers. Percentages close to these were found downstream of this teaching (70% of students opted for the correct proposal).

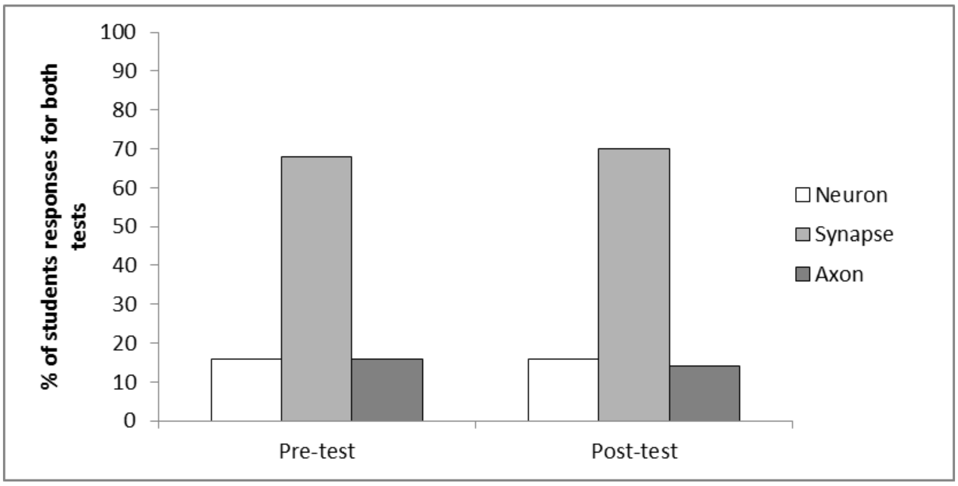

Figure 3. Percentages of responses: the structure responsible for the transmission of nervous message.

For Question 4 (Q4) about the definition of the synapse (Fig.4), the results obtained upstream of teaching the concept of neurotransmission show that 36% of students surveyed selected the correct definition of the synapse ((a) Contact area specialized in the transmission of nerve messages) while the rest of students (64%) checked incorrect synapse definitions ((b) formed by a pre-synaptic and postsynaptic elements for 22% of students, or (c) the space between the pre-synaptic element and post-synaptic element for 42% of students surveyed). The data obtained downstream of this teaching show that the percentages of the correct answers have increased to reach 52%.

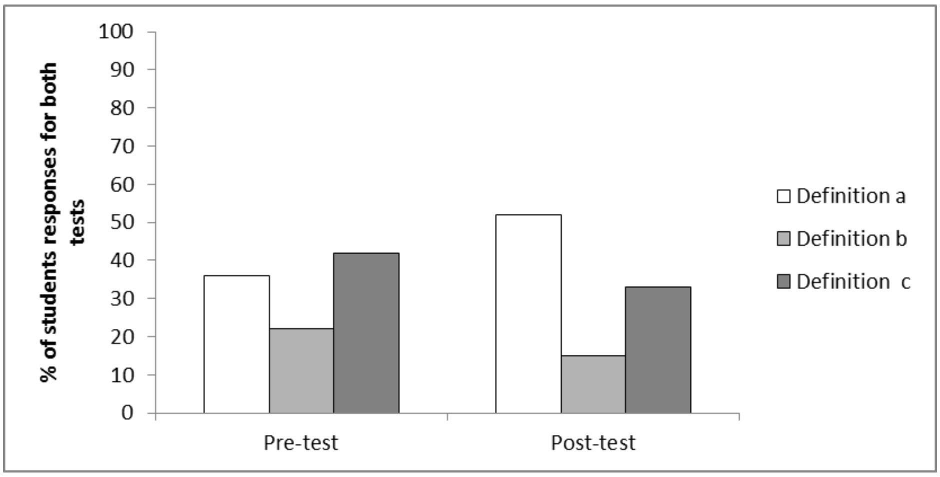

Figure 4. Percentages of responses: the definition of the synapse.

In Question 5 (Q5), concerning the number of the synapse types (Fig. 5), the results obtained upstream the teaching of the neurotransmission concept show that 40% of the students interviewed answered correctly to knowing that there are two functional types of synapse. In contrast, 60% of students checked incorrect definitions (3 synapse functional types or 5 synapse functional types). Downstream of this teaching, the majority of the students (53%) opted for the correct answer (2 functional types of synapse).

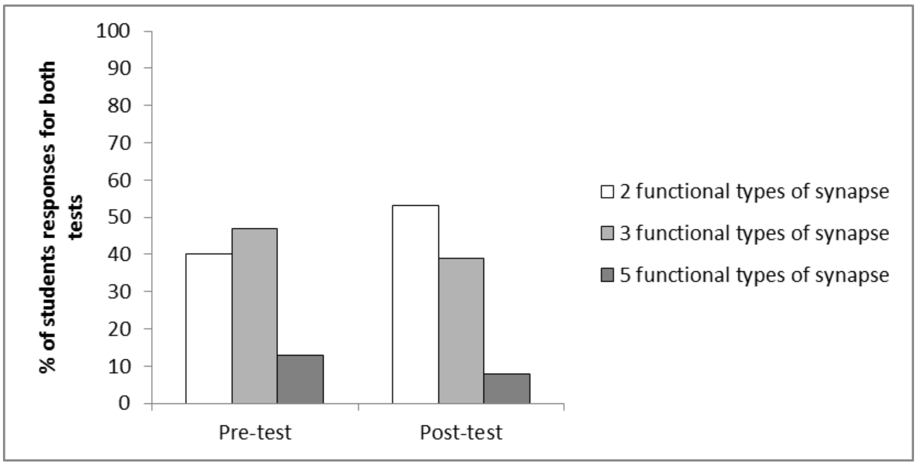

Figure 5. Percentages of responses: the number of the functional type of the synapse.

In Question 6 (Q6), students were asked to give the diagram of a synapse (Fig.6). The results show that the majority of students (94%) upstream of teaching neurotransmission could not draw the correct diagram of the synapse. Downstream of this teaching, even with a little improvement, the students who could not schematize the synapse remain a majority (64%).

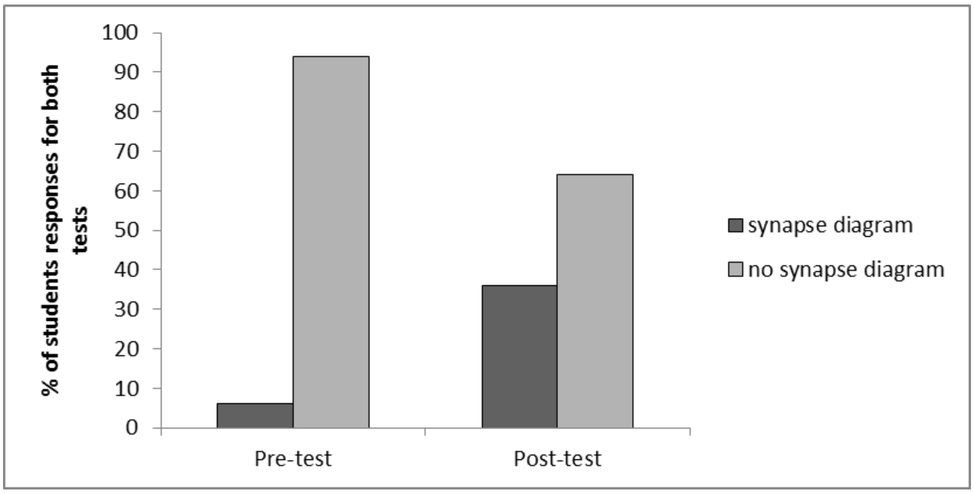

Figure 6. Percentages of responses: the diagram of the synapse.

Question 7 (Q7) is articulated around the neuron (Fig.7). A student who has acquired the concept of the neuron must tick simultaneously the two correct and complementary propositions (a + c) namely that: (a) the neuron is a nerve cell composed of a nucleus surrounded by structures in the form of stars (dendrites) and a long prolongation (axon) and (c) endowed with specific properties which are excitability, propagation and transmission of nervous message. This is the case for 26% of students surveyed, which seems to indicate that the concept is not acquired. We note that 64% chose the definition (a) which consists of the anatomical description of the neuron, these students are, therefore, limited to the declarative level of the concept.

Downstream of this teaching, we observed an increase in the percentage of correct answers that reaches 50%, where students ticked both definitions (a + c) to give the complete definition of the neuron concept. In contrast, 47% students ticked a single correct but incomplete proposal to fully acquire the concept of the neuron, which shows that a priori these students were able to reach a certain level of conceptualization, allowing them to acquire the concept of the neuron.

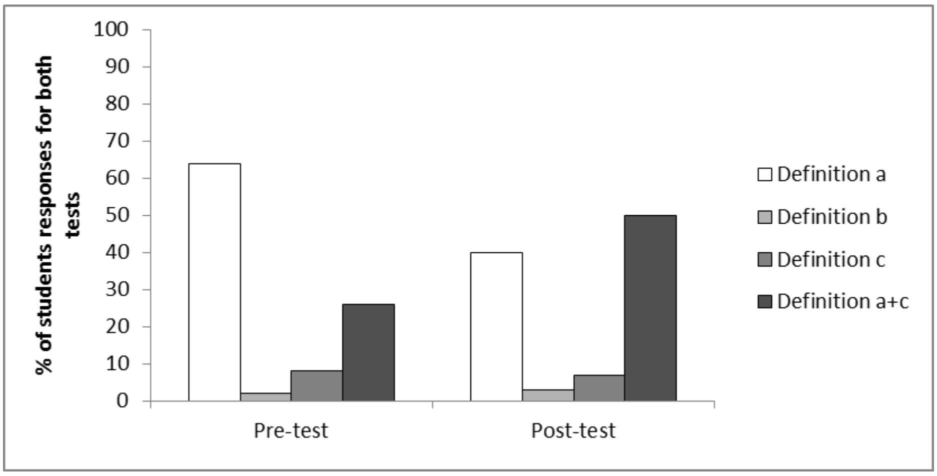

Figure 7. Percentages of Responses: The Definition of the Neuron.

Question 8 (Q8) consists of giving the diagram of the neuron (Fig.8). The answers were in line with the previous question, namely that the surveyed students do not really have the ability to schematize the concept of the neuron. Indeed, the majority of student in the pre-test (62%) and the post-test (58%) could not give the correct diagram of the neuron.

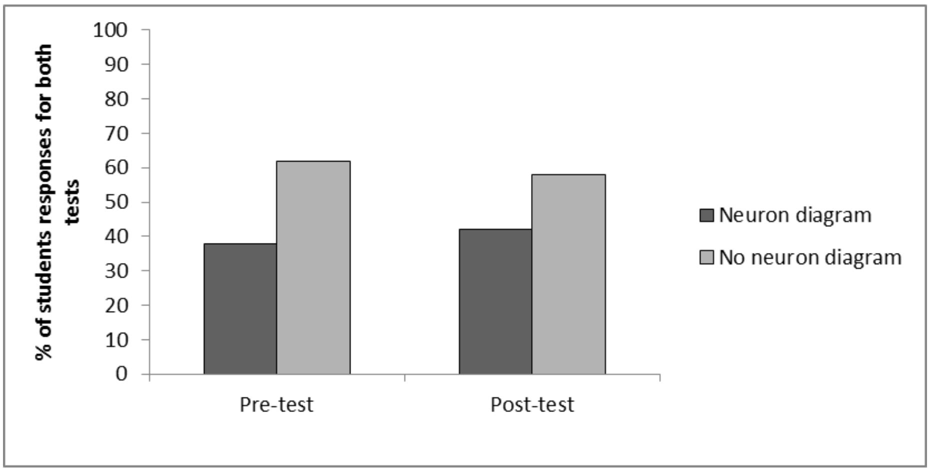

Figure 8. Percentages of Responses: The Neuron diagram.

In Question 9 (Q9), it was requested from the students to define the concept of neurotransmetter (Fig. 9). The first finding is that 27% of students have given incomplete correct definitions while 73% of the rest gave incorrect definitions.

The correct and complete answer (the neurotransmitter is a chemical substance synthesized by a neuron at the level of a synapse and capable of transmitting or carrying information (nervous message) from a neuron towards a target cell) has only been formulated by 9% of the surveyed population. As for the 18% of the remaining students, they gave fragments of definition such as chemical substance for 8% of students; chemical substance synthesized by a neuron for 5% of them and transmits information from one neuron to another for 5% of students surveyed.

This finding improved after teaching, there was a decrease in the percentage of incorrect answers reaching 42% and an increase in the percentage of students who formulated complete or incomplete correct answers reaching 58%.

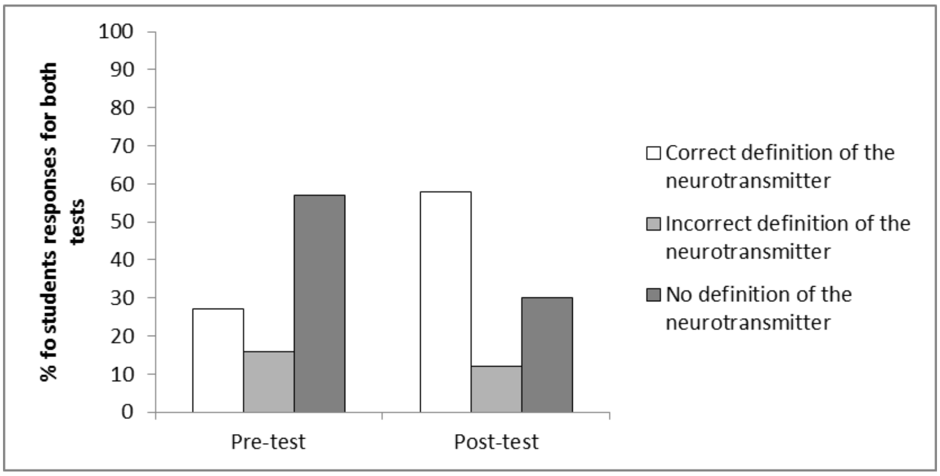

Figure 9. Percentages of Responses: The Definition of the Neurotransmitter.

In Question 10 (Q10), students were asked to define the concept of neurotransmission (Fig. 10). Upstream of this teaching, the majority of students (82%) gave an incorrect definition of the concept (34% of students defined it as a synapse, and (48%) of other students receive it as a nervous message). In contrast, 18% of students surveyed were able to give a correct definition of the neurotransmission concept (it refers to the passage of nervous message across a synapse through the release of a neurotransmitter liberated into the synaptic cleft and fixed by specific receptors present on the postsynaptic surface).

Downstream the teaching of neurotransmission, we observed an increase in percentage of students surveyed, who formulated the correct definition of the neurotransmission concept which reached 55%. According to this question, it appears that the majority of the surveyed students integrated the concept of neurotransmission after a reinforced teaching by adopting an interactive approach in the course.

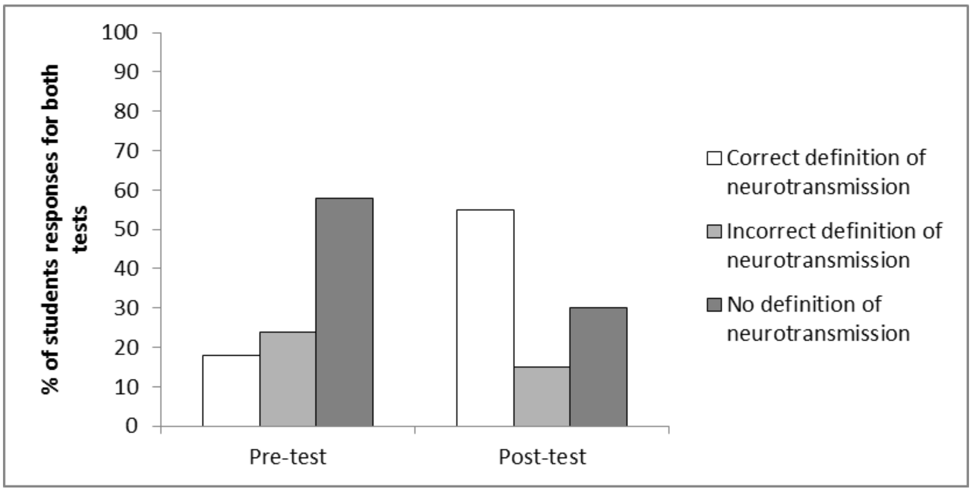

Figure 10. Percentages of responses: The Definition of Neurotransmission.

The results obtained upstream (pre-test) of the neurotransmission teaching shows that the average value of the incorrect answers percentage of students reached 65% whilst the percentage of the correct answers record an average value of 33%. Indeed, this indicates that there is a dominance of misconceptions among these students (Fig. 11).

The results obtained from the post-test show that there is a significant difference between the average values of the percentages of the correct answers and the incorrect ones. Moreover, there is a significant increase in the average value of the correct answers percentages which reached 60%. On the contrary, there is a decrease which reached 40% of the average value of the incorrect answers percentages (Fig. 11).

These data show a positive and significant evolution in the students' conceptions after adopting an interactive approach in the teaching of neurotransmission. It seems that they have reached an acceptable level of conceptualization and have assimilated the concept of neurotransmission and these associated concepts.

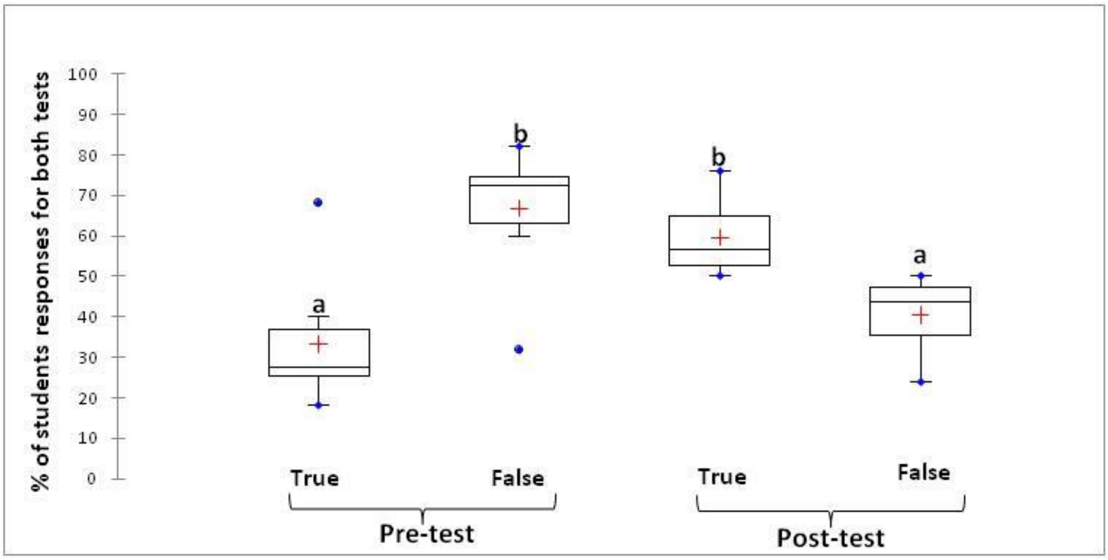

Figure 11.Percentages of True and False student responses upstream (pre-test) and downstream (post-test) of neurotransmission learning. The boxes (Box-plots) represent the minimum and maximum values, the median the 25th and 95th quartiles. Mean values (+); Outliers (.). Values with different letters (a and b) are significantly different (p <0.05).

Discussion

The results obtained from the pre-test highlight the dominance of misconceptions and incomplete conceptions about concepts related to neurotransmission among the majority of surveyed students.

Indeed, for the two questions (Q1) and (Q2), we noted a dominance of the electrical conception (propagation and nature of the nervous message). This finding can be explained by the fact that these concepts are introduced for the first time in high school (1st year of the Baccalaureate of Life and Earth Sciences) by the electrical register, and that these students, therefore, remain focused on the electrical conception even if they have approached the chemical part of the concept. This same result was reported by Laribi et al. (2010) in explaining the conception construction of the nervous message transmission by high school pupils that highlights the persistence of electrical conception among these students.

For the question (Q3) about the students' conceptions concerning the structure responsible for the transmission of nervous message. The results obtained upstream of the neurotransmission teaching showed that this competence seems mastered by the majority of surveyed students.

The student responses to questions (Q4), (Q5) and (Q6) about the synapse (definition, synapse number and synapse pattern) and questions (Q7) and (Q8) concerning the definition of the neuron and its explanatory diagram, showed that these two concepts are not assimilated by the majority of students since they did not opt for the correct definitions and could not schematize these concepts. This highlights the dominance of misconceptions among the majority of these students, which shows the limited effect of the sequence of learning on the appropriation of these two notions (synapse and neuron). This result is consistent with a study on the nervous system conducted by Bec and Favre (1996), who showed that the Biology course has a limited effect on the appropriation of concepts by the pupils of the final year of higher school. Also, the results of the two questions (Q6) and (Q8) dealing with the schematization of the synapse and the neuron showed that this competence is not mastered enough by the surveyed students. This finding is consistent with a study conducted by Kaddari (2005), highlighting the difficulties of atomistic iconic perception by students at university.

For the results of the two open-ended questions (Q9) and (Q10), it appears that the majority of surveyed students did not integrate the chemical conception since high school to be able to define correctly the concepts of neurotransmitter and neurotransmission. Some of them confuse the neurotransmitter with neuron and neurotransmission with synapse. These confusions showed the presence of problems related to the scientific vocabulary used among these students (Thouin, 2004). The rest of surveyed students have tried to define the two concepts (neurotransmitter and neurotransmission), but their proposals remain fragmented, which shows that their scientific knowledge is not well structured and not consistent.

This finding seems to highlight that students have approached their course on neurotransmission with alternative conceptions and misconceptions which may hinder the learning and deepening of this content. This result is in agreement with a previous study during 2015-2016 academic year, where the concepts of neurotransmission were far from being mastered by the majority of students. In fact, the results of present study are very consistent with data from literature review on teaching and learning scientific concepts showing that initial conceptions sometimes constitute barriers/obstacles to learning (Ozmen, 2004; Schneider & Stern, 2010; Abraham, Perez & Price, 2014; Kampourakis, Silveira & Strasser, 2016).

In this year's (2016-2017) ongoing experiment, the same test was administered to students at the end of neurotransmission course. Unlike the previous year, the post-test data indicate that the adoption of an interactive pedagogical approach during the teaching/learning process of neurotransmission concept could promote a conceptual change among these students. Indeed, for both questions (Q1) and (Q2), the percentage of correct answers that has increased, indicates that they have integrated the chemical conception into their interpretation of the neurotransmission concept. These results showed that these students are able to go beyond their initial conceptions and to build a coherent knowledge about the neurotransmission concept taught with an interactive pedagogical approach. This finding is in line with the data of the study conducted by Potvin and Thouin (2003) on the qualitative understanding of physics-mechanics and the evolution of learners' conceptions after the adoption of an appropriate approach in the learning sequence.

The progression of students' conceptions was also noted in the questions of (Q3), (Q4) and (Q5) about the concept of the synapse and also for the question (Q7) on the neuron concept. These two concepts seem to be mastered by half of the surveyed sample. The same observation was noted in the two open-ended questions of (Q9) and (Q10) where students were able to better define the notions of the neurotransmitter and neurotransmission. There is an evolution in the correct students' conceptions, which points the positive impact of the interactive approach on the learning of neurotransmission at university.

The evolution of conceptions was less apparent in questions of (Q6) and (Q8) inviting students to give explanatory diagrams of the synapse and the neuron. Indeed, the students seem not to have developed the ability to schematize these concepts. This finding is consistent with a study conducted by Kaddari (2005), highlighting the difficulties of the atomistic iconic perception by students at university.

The adopted instruction during the learning sequence of neurotransmission has a positive effect on the evolution of students' conceptions. It, therefore, seems that they have reached an acceptable level of conceptualization, and they have assimilated the concept of neurotransmission and these associated concepts. Indeed, the process of conceptual change has, therefore, taken place which validated the hypothesis at the origin of this study stating that this interactive approach could help students to progress and build a coherent scientific knowledge. The result of this experiment confirms the reflection of DiSessa (1993, 1996) stipulating that the conceptions would rather be built when they are solicited. Thus, we can stimulate the process of conceptual change among students so that they continually build and reconstruct explanations that serve to interpret and understand the concepts studied and go beyond the static and rigid sets of long-standing and ingrained conceptions.

Conclusion

According to the pre-test data, the foundations of neurotransmission are far from being assimilated by students even they have already studied these notions in high school. Indeed, the persistence of pre-acquired knowledge, the dominance of misconceptions about the concept of neurotransmission among these students and the limited effect of the learning sequence on the appropriation of this concept can block the evolution of the students' conceptions to properly acquire the concept of neurotransmission with adding the difficulty of schematizing the concepts. This finding seems to highlight that these difficulties may hinder the learning and deepening of this content by students.

However, the results obtained from the post-test after adopting an interactive approach on the learning process shows that there is a significant evolution of students 'conceptions, which confirmed the positive effect of this interactive approach which allows students to build and reconstruct explanations that serve to interpret and understand the concepts studied and go beyond their initial conceptions. This induces to stimulate the conceptual change process among students to build an adequate and coherent scientific knowledge.

In the light of the results obtained from this study, it would be necessary for teachers to introduce tools and strategies which focus on the students by taking into consideration their initials conceptions during the learning process. In order to stimulate the conceptual change process among these students as well as to achieve an effective learning of scientific content at the university.

Then, it would be interesting to privilege the teaching of transdisciplinary notions by making students acquire a scientific culture based on the practice of the procedures instead of too encyclopedic notional contents.

References

Abraham, J. K., Perez, K. E., & Price, R. M. (2014). The dominance concept inventory: A tool for assessing undergraduate student alternative conceptions about dominance in Mendelian and population genetics. *CBE-Life Sciences Education*, 13(2), 349-358.doi: 10.1187/cbe.13-08-0160

Astolfi, J. P., & Peterfalvi, B. (1993). Obstacles et construction de situations didactiques en sciences experimentales [Obstacles and construction of didactical situations]. *Aster,* (16), 103-141.

Bachelard, G. (1938). *La formation de l'esprit scientifique* [The training of scientific spirit]. Paris, France: Vrin.

Bec, J. L., & Favre, D. (1996). Le systemenerveux dans le programme de Biologie: Quel(s) concept(s) veut-on enseigner? [The nervous system in the Biology program: What concept(s) to teach?]. *Trema-Lesspecificites de la biologie et de son enseignement*[The specificities of biology and its teaching], (9-10), 97-104.

Bertrand, C. (2014). *Soutenir la transformation pedagogique. Rapport de ministere de l'enseignement superieur et de la recherche [Support the educational transformation: Report of the Ministry of Higher Education and Research*]. Retrieved from https://www.letudiant.fr/static/uploads/mediatheque/EDU_EDU/2/5/253025-rapport-pedagogie-vdiff-01-07-14-original.pdf

Bireaud, A. (1990). *Les methodes pedagogiques dans l'enseignement superieur* [The teaching methods in higher education]. Paris, France : Editions d'Organisation.

Bouayad, A. (2015). *Liaison chimique : conceptions et difficultees d'apprentissage en cycle Licence* [Chemical Bonding: conceptions and learning difficulties in bachelor degree] (Unpublished doctoral dissertation). Sidi Mohamed Ben Abdellah University, Fez, Morocco.

Bouchard, R., & Parpette, C. (2007). Initiation a une discipline universitaire, commentaire terminologique general et enseignement du vocabulaire specialise / Le cas des CM de Droit [Introduction to a university discipline, general terminological commentary and teaching of specialized vocabulary / The case of MC of Law]. In E. Calaque (Ed.), *Enseignement et apprentissage du lexique [Teaching and learning lexicon] (pp.* 199-211). Brussels, Belgium: De Boeck.

Clarac, F., & Ternaux, J. P. (2008). *Encyclopedie historique des neurosciences. Du neurone a l'emergence de la pensee* [Historical Encyclopaedia of Neuroscience. From the neuron to the emergence of thought].Brussels, Belgium: De Boeck.

DeVecchi, G. (1992). *Aider les eleves a apprendre* [Help students to learn]. Paris, France: Hachette Education.

DiSessa, A. A. (1993). Toward an epistemology of physics. *Cognition and Instruction*, *10*(2/3), 105-225.

DiSessa, A. A. (1996). What do"just plain folk" know about physics? In D. R. Olson & N. Torrance (Eds.), *Handbook of Education and Human Development* (pp. 709-730). Malden: MA: Blackwell Publishing.

Disessa, A. A. (2002). Why "conceptual ecology" is a good idea. In M. Limon & L. Mason (Eds.).*Reconsidering conceptual change: Issues in theory and practice* (pp.28-60).Dordrecht, The Netherlands: Springer.

Doudin, P. A., & Tardif, E. (2016). *Neurosciences et cognition : Perspectives pour les sciences de l'education* [Neuroscience and cognition: Perspectives for the sciences of education]. Brussels, Belgium: De Boeck.

Driver, R. (1989). Student's conceptions and the learning of science. *International Journal of Science Education, 11*(5), 481-490.

Duit, R. (1999). Conceptual change approaches in science education. In W. Schnotz, S. Vosniadou & M. Carretero (Eds.). *New perspectives on conceptual change* (pp. 263-282). Bingley, UK: Emerald Group Publishing Limited.

Dupont, J. C. (1999). *Histoire de la neurotransmission*[History of neurotransmission]. Paris, France: PUF-Presses universitaires de France.

El Hassouny, E. H. (2014). *Les TICEs en classes de sciences physiques: Enjeuxetetude d'impact* [ICTs in physical science classes: Issues and impact study].(Unpublished doctoral dissertation). Sidi Mohamed Ben Abdellah University, Fez, Morocco.

Felouzis, G. (2003). *Les mutations actuelles de l'Universite* [The current changes of the university] (1st ed.). Paris, France: PUF-Presses universitaires de France.

Giordan, A. (1996). Les conceptions de l'apprenant comme tremplin pour l'apprentissage...! [The learner's conceptions as a springboard for learning...!]. *Sciences Humaines* [Human Sciences].Retrieved fromhttp://www.andregiordan.com/articles/apprendre/concepttapp.html

Giordan, A. (1998). *Apprendre!* [Learn!]. Paris, France: Debats Belin.

Giordan, A., Girault, Y., & Clement, P. (1994). *Conceptions et connaissance* [Conceptions and knowledge]. Bern, Switzerland: Peter Lang.

Glickstein, M. (2006). Golgi and Cajal: The neuron doctrine and the 100th anniversary of the 1906 Nobel Prize. *Current Biology*, *16*(5), 147-151.doi: 10.1016/j.cub.2006.02.053

Hewson, P. W., Beeth, M. E., & Thorley, N. R. (1998).Teaching for Conceptual Change. In B. J. Fraser & K. G. Tobin (Eds.). *International Handbook of Science Education* (pp.199-218). Dordrecht, The Netherlands: Springer Netherlands.

Hewson, P. W., & Thorley, N. R. (1989). The conditions of conceptual change in the classroom. *International Journal of Science Education, 11*(5), 541-553.

Houssaye, J. (1993). *La pedagogie: une encyclopedie pour aujourd'hui* [Pedagogy: an encyclopedia for today]. Paris, France: ESF Editeur.

Joshua, S., & Dupin, J. J. (1989). *Representations et modelisation : le debat scientifique dans la classe et l'apprentissage de la physique* [Representations and modeling: the scientific debate in the classroom and the learning of physics]. Bern, Switzerland: Peter Lang.

Joshua, S. & Dupin, J. J. (1999). *Introduction a la didactique des sciences et des mathematiques* [Introduction to the science and mathematics didactics]. Paris, France: PUF- Presses universitaires de France..

Kaddari, F. (2005). *De l'atome a l'atomistique. Etude des principes et des conceptions* [From the atom to the atomistic. Study of principles and conceptions] (Unpublished doctoral dissertation). Sidi Mohamed Ben Abdellah University, Fez, Morocco.

Kampourakis, K., Silveira, P., & Strasser, B.J. (2016). How do preservice biology teachers explain the origin of biological traits? A philosophical analysis. *Science Teacher Education, 100*(6), 1124–1149.

Kochkar, M. (2007). *Les determinismes biologiques. Analyse des conceptions et des changements conceptuels consecutifs a un enseignement sur l'epigenese cerebrale chez des enseignants et des apprenants tunisiens* [Biological determinisms: Analysis of conceptions and conceptual changes resulting from teaching on cerebral epigenesis among Tunisian teachers and learners].(Unpublished doctoral dissertation).University of Tunisia & University of Claude Bernard – Lyon 1, Villeurbanne, France.

Laribi, R., Marzin, P., Sakly, M., & Favre, D. (2010). Etude des conceptions des eleves de premiere et de terminale scientifiques sur la transmission synaptique en Tunisie et en France [Conceptions study of the first and final scientific students on synaptic transmission in Tunisia and France], *RDST,* (2), 193-214.

Loewi, O. (1935). The ferrier lecture on problems connected with the principle of humoral transmission of nervous impulse. *Proceedings of the Royal Society of London. Series B, Biological Sciences*, *118*(809), 299-316. doi: 10.1098/rspb.1935.0058

Macbeth, D. (2000). On an actual apparatus for conceptual change. *Science Education,* 84(2), 228-264.

Migne, J. (1994). Pedagogie et representations [Pedagogy and representations]. *Education permanente* [Permanent education], (119), 11-31.

Ozmen, H. (2004). Some Student Misconceptions in Chemistry: A Literature Review of Chemical Bonding. *Journal of Science Education and Technology, 13*(2), 147-159.

Paccaud, M. (1991). Les conceptions comme levier d'apprentissage du concept de respiration [Conceptions as a learning lever for the breathing concept]. *Aster*, (13), 35-58.

Potvin, P., & Thouin, M. (2003). Etude qualitative d'evolutions conceptuelles en contexte d'explorations libres en physique mecanique au secondaire [Qualitative study of conceptual evolutions in the context of free explorations in secondary mechanical physics]. *Revue des sciences de l'education* [Journal of Educational Sciences]*, 29*(3), 525–544.

Sadi. O. (2014). Students' conceptions of learning in genetics: A phenomenographic research. *Journal of Turkish Science Education, 11*(3), 53-63.

Schneider, M., & Stern, E. (2010). The developmental relations between conceptual and procedural knowledge: A multimethod approach. *Developmental Psychology, 46*(1), 178–192.

Soudani, M. (1998). *Conceptions et obstacles dans l'enseignement-apprentissage de l'oxydoreduction: Contribution a une epistemologie appliquee a la construction curriculaire* [Conceptions and obstacles in teaching and learning of oxidation-reduxtion concepts. Contribution to an epistemology applied to the curriculum construction](Unpublished doctoral dissertation). University of Montpellier II, Montpellier, France.

Thouin, M. (2004). *Enseigner les sciences et la technologie au prescolaire et au primaire* [Teaching science and technology at the preschool and elementary]. Quebec, Canada: MultiMondes.

Viau, R. (1994). *La motivation en contexte scolaire* [Motivation in school context]. Paris, France: De Boeck.

Viennot, L. (1988). Obstacles epistemologiques et raisonnements en physique: tendance au contournement des conflits chez les enseignants [Epistemological barriers and reasoning in physics: a tendency for teachers to avoid conflict]. In B. Bernadrz & C. Garnier (Eds.).*Construction des savoirs : obstacles et conflits* [Building knowledge: obstacles and conflicts](pp. 117-129). Montreal, Canada: CIRADE.

Vosniadou, S. (2002). On the nature of naive physics. In M. Limon & L. Mason (Eds.), *Reconsidering conceptual change: Issues in theory and practice* (pp. 61-76). Dordrecht, The Netherlands: Kluwer Academic.

Vosniadou, S., & Ioannides, C. (1998). From conceptual development to science education: a psychological point of view. *International Journal of Science Education, 20*(10), 1213-1230.