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Moroccan University Students' Conceptions of Neurotransmission

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ABSTRACT

Neurotransmission represents a key concept in the history of biology. The objective of this study is to elicit Moroccan university students' conceptions of neurotransmission and highlight potential difficulties and obstacles that may hinder its effective learning. A questionnaire was administered to 120 science students as a pre-test. After the neurotransmission course at Dhar El Mahraz Faculty of Science, the same questionnaire was re-administered. The results of the study appeared that the majority of the science students had deficiencies at integrating and assimilating the concept of neurotransmission and other related concepts.

Keywords: Conception, nervous message, neurotransmitter, neurotransmission, synapse.

INTRODUCTION

Neuroscience employs several scientific disciplines to understand the nervous system and its functioning (Clarac & Ternaux, 2008). Even though neuroscience firstly emerged as a branch of biology and medicine, advances in scientific knowledge and methods of the nervous system (biology, biochemistry, pharmacology, anatomy and physiology) has considerably extended its scope.

Nerve physiology, an integral part of neuroscience, includes great technical facilities for further characterized discoveries (Debru, 1999). Nerve physiology also embraces the chemical neurotransmission, which is opposite to theories of electrical and chemical nervous functioning. Hence, it represents a crucial moment in the history of biology to unveil cellular communication and the language of cells (Dupont, 1999). Chemical neurotransmission refers to the passage of nervous message across a synapse that releases a neurotransmitter stored in pre-synaptic vesicles. Specific receptor's synaptic cleft and fixation move from pre-synaptic surface to post-synaptic surface (Loewi, 1935).

Given the importance of the neurotransmission concept in biology (Dupont, 1999). The basic notions were introduced in high schools education through a didactic transposition

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adapted to the cognitive level of pupils. The deepening of these notions continues through the course taught at the second year of university. The aim of this course is to achieve the following goals: (a) to allow students to understand the integrity and identity of an organism that requires its operational modulation and control to ensure intercellular communication and necessary information transfers; (b) to acquire basic notions concerning the physiology of excitable elements and intercellular communication (nerve cells, muscle cells and endocrine cells).

Despite an increase in the importance of neurotransmission content, how to teach and learn it has still been unexplored as compared to other life science topics such as digestion, respiration. Further, students find the neurotransmission difficult and have lower scores at the summative assessments. Moreover, previous researches on teaching and learning neurotransmission state that students possess some conceptual confusions and difficulties (Astolfi, 1992; Darley, 1994; Bec & Favre, 1996; Laribi et al., 2010). Indeed, only one study by Darley (1994) reported that university biology students at the second-year had some confusions at defining term 'action potential'. Tremendous researchers have focused on students' conceptions of science concepts and identified factors hindering student learning through didactic strategies (Jonnaert, 1988; Mein, 1988; Mein & Clément, 1988; Clément, 1994; Albanese & Vicentini, 1997; Ozmen, 2004; Kaddari, 2005; Kochkar, 2007; Schneider & Stern, 2010; Abraham, Perez & Price, 2014; Kampourakis, Silveira & Strasser, 2016; Luksa et al., 2016).

It is generally accepted that the conceptions constitute an explanation system permitting learners to interpret various scientific situations. This hypothesis is of interest in the current study. Whose purposes are to elicit Moroccan university students' conceptions of neurotransmission and highlight potential difficulties and obstacles that may hinder its effective learning. So, the following research questions guide the current study: (1) Do university students have basic knowledge of neurotransmission? (2) Does this course enable them to acquire advanced scientific knowledge?

Theoretical Framework

This study relies on the notion of "conception," which is defined as a body of spontaneous knowledge representing the student's explanatory models and reading schemes of reality **(**Martinand, 2009; Giordan & Martinand, 1988).

Astolfi and Develay (1989) see conceptions as an "existing conceptual framework in mind", while Giordan and Martinand (1988) consider it as a "frame of reference" and/or "preliminary ideas" held by a student. The term "misconception" means a "deviation from scientific knowledge of reference" (Novak, 1984), and/or "false ideas" (Sencar et al., 2001; Gonzalez, 1997; Schmidt, 1997). Indeed, the learner understands the world through his previous experiences/conceptions. Hence, he constitutes an explanation system to read and interpret reality. In this sense, it is commonly accepted that new knowledge interacts with pre-existing one in conceptual framework (Bec & Favre, 1996).

Students' learning difficulties of biology may result from their pre-conceptions. These pre-conceptions are also a part of mental knowledge systems. They correspond to a working coherent system interpreting scientific phenomena (Jonnaert, 1988). For this reason, conceptions are resistant to conventional teaching and persist throughout schooling (Astolfi & Peterfalvi, 1993). Any learning obstacle/difficulty at higher education may stem from previous schooling years (Darley, 1994). So, the current study claims that if science students have difficulties at acquiring and assimilating biological concepts in higher education, this may come from their conceptions or pre-existing experiences at secondary school classes.

Learning means a transformation of conceptions (conceptual change) to a more advanced and abstract issue/knowledge (Joshua & Dupin, 1999). DiSessa (2002) addresses that this conceptual change moves from a fragmented knowledge to a well-structured one, whilst Vosniadou (2002) views this transformation as an assimilation of new knowledge to the existing structures.

RESEARCH METHODOLOGY

To test research questions of the study, we followed the subsequent methodology:

I) To determine the content of neurotransmission at the university level, we used the curriculum and course materials written by the teachers. Thereby, they defined scope and content of the concept. Indeed, the nervous communication is a motor command between a nerve cell and a muscular cell. The transmission of the message from one cell to another requires a particular structure, called synapse, and neurophysiological mechanisms involving these synapses and their correspondence to neurotransmission. The neurotransmission concept, which has some roots in the basic sciences, is taught in the second year of the university (Semester 4).

The physiology of nerve and muscle cells course treats neurotransmission through the functional anatomy of the neuromuscular junction or neuromuscular synapse at the base of the motor command. This study focused on the following concepts: neuron, synapse, neurotransmitter and neurotransmission.

II) To overview the university students' "expected" conceptual profiles and estimated there prerequisites of these notions, we examined the syllabus content of high school curriculum dealing with neurotransmission or synaptic transmission. We counted on “life and earth science” textbook used in the first-year of baccalaureate. Thus, we identified such basic concepts as the nature of nervous message, neuron, synapse, and neurotransmitter.

III) Given earlier steps for high school and university students, we developed a questionnaire as a diagnostic tool articulated around the basic fundamental notions of neurotransmission.

This questionnaire comprised of upstream and downstream of neurotransmission teaching. Upstream of neurotransmission embraced students' pre-existing knowledge and prerequisites before learning neurotransmission at the university. Downstream of neurotransmission covered how students evolve their knowledge after the course at the university. Therefore, we estimated whether their performances would have developed.

In fact, the students' conceptual growth may highlight their obstacles and difficulties of the neurotransmission concept.

a) Description of the questionnaire

The questionnaire consisted of close-ended questions, open-ended questions and schema to a better understanding of the students' conceptions.

- Six close-ended questions (Q1-Q5 and Q7) requested students to choose the appropriate answers in the multiple-choice format, which limits the answer type and facilitates its treatments.
- Two questions (Q6 and Q8) asked students to draw their schemas of the synapse and neuron concepts.
- Two open-ended questions (Q9 and Q10) allowed students to freely answer without any structured format. Hence, we purposed to elicit students' views and varied answers.

Different types of the questions may enable us to check the implications of the subjects and ensure the validity of the questionnaire.

b) Sampling and conditions of administrating the questionnaire

It was administered to 120 second-year (semester-4) science-major students enrolled to the Life Sciences at Dhar El Mahraz Faculty of Science during the 2015-2016 academic year.

As aforementioned, the questionnaire was administered before and after neurotransmission education. That is, we firstly passed over the questionnaire to the students as a pre-test. Then, after the neurotransmission education (which took about a month and half), we re-administered the questionnaire to them as a post-test in an amphitheater for the same population.

The students anonymously responded the questionnaire about 30-45 minutes; also we informed them that their responses to the questionnaire would not be evaluated for any credit.

c) Data Analysis

The students' responses to the closed questions were imported into the Excel 2007, while those for the open-ended questions were analyzed by means of the key words. Data from the pre-test and post-test were entered into an Excel spreadsheet and presented within tables and figures through frequencies and percentages.

RESULTS

To highlight the students' conceptual growth, the percentages of their answers to the pre-test and post-test were reported in the same histogram.

a) The propagation of nervous message

Their responses to question 1 (Q1), on the upstream phase of the neurotransmission education which is about the propagation of nervous message (see Figure 1), showed that 72% of the students depicted that the nervous message spread continuously, while 28% of them said that the nervous message progressed through a discontinuous manner.

As seen from Figure 1, the downstream phase of the neurotransmission education revealed a small variation for the data obtained. 38% of the students selected the correct choice (the nervous message propagates through a discontinuous manner), whilst 62% of them marked that the spread of nervous message was continuous. This showed that even after an extensive teaching, the majority of students tended to represent a continuous nervous message.

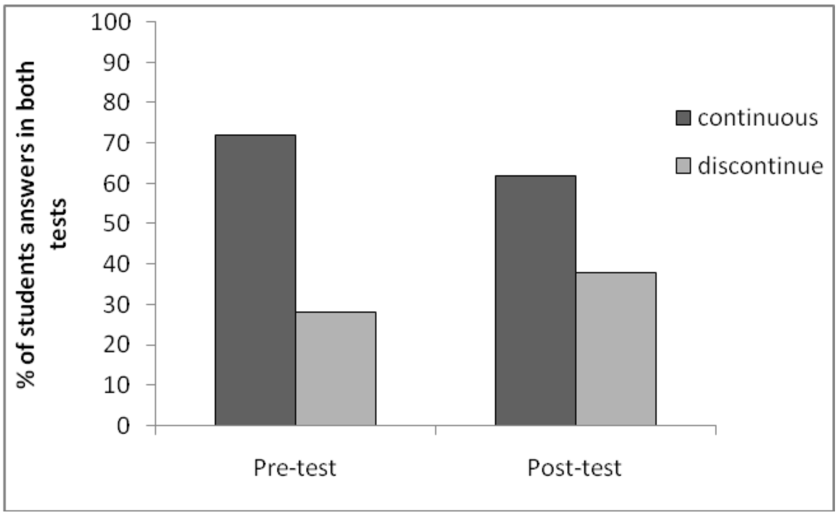

Figure 1. Percentages of the students' answers to the propagation of nervous message.

b) The nature of the nervous message

Their responses to the question 2 (Q2) (which focuses on the nature of the nervous message) pointed that only 33% of them chose the correct one (the nerve message is both electrical and chemical in nature) for the pre-test. On the other hand, two-third of them marked the wrong answers (the nervous message is only electrical in nature for 42% of students; and the nervous message is chemical in nature for 25% of students).

Those findings do not seem to improve after the neurotransmission course (see Figure 2). In fact, half of students implied that the nervous message was electrical in nature, whereas 23% of them stated that the nervous message was chemical in nature. 27% of the students understood the nature of the nervous message (chemical and electrical).

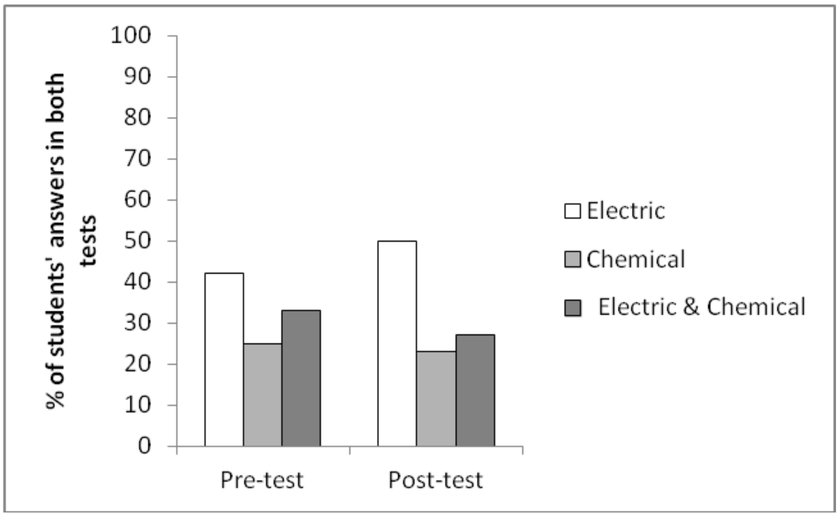

Figure 2. Percentages of the students' answers to the nature of the nervous message.

c) The responsible structure for the transmission of nervous message

Their responses to question 3 (Q3) (determining the responsible structure for the transmission of the nervous message (neuron, synapse or axon) showed that 76% of students selected the correct choice (the synapse is the responsible structure for the transmission of nervous message) for the pre-test. Further, 24% of them marked incorrect ones (the transmission is done by the neuron for 12% of students; and it is by the axon for 12% of them) (see Figure 3).

As can be seen from Figure 3, the downstream phase of the neurotransmission education indicated no change in the students' answers. In other words, majority of them (74%) chose the correct answer, while some of them (26%) marked the incorrect answers.

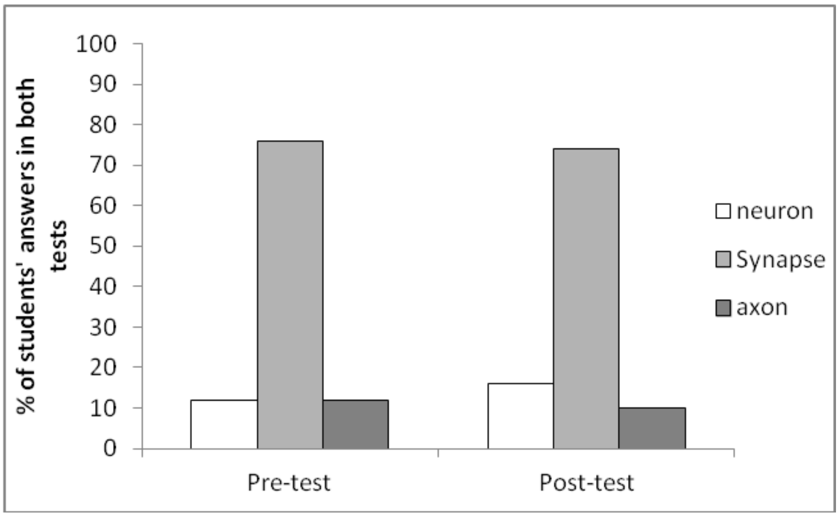

Figure 3. Percentages of the students' answers to the responsible structure for nervous message transmission.

d) The synapse definition

The students responses to question 4 (Q4) (which is about the definition of the synapse) upstream the teaching of neurotransmission concept, showed that 52% of them chose the correct definition of the synapse ((a) Contact area specialized in the transmission of nerve messages). Further, 48% of them marked the incorrect synapse definitions ((b) pre- and post-synaptic elements forms synapse, or synapse designates the space between the pre-and post-synaptic elements (c)). As seen from Figure 4, the downstream phase of the neurotransmission education showed that the percentages of the incorrect answers slightly increased (61%). Their responses to the pre- and post-tests revealed that more than half of them were unable to exactly define the synapse concept.

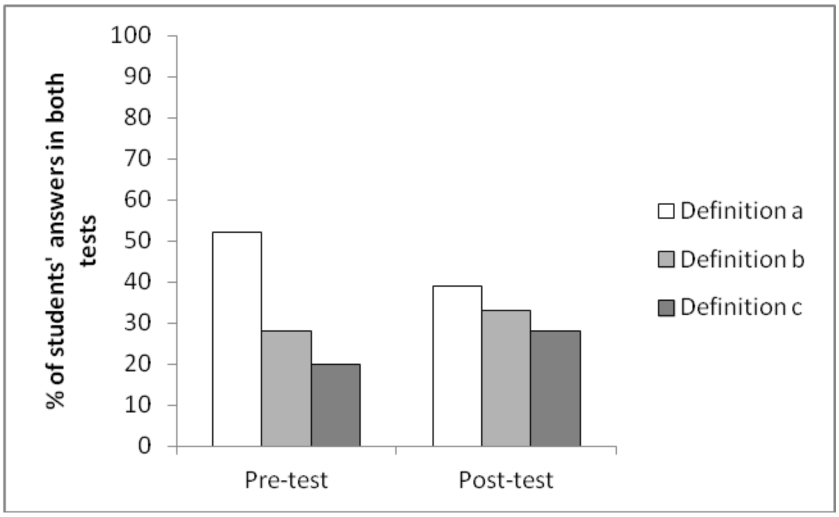

Figure 4. Percentages of the students' answers to the synapse definition.

g) The number of functional type of the synapse

Given their responses to question 5 (Q5) (which is about the type number of the synapse) on the upstream phase of the neurotransmission education showed that 40% of students correctly answered two functional types of synapse. In contrast, 60% of them selected incorrect answers (three functional types of synapse--47%; and five functional synapse types--13%) (see Figure 5). Downstream of this teaching, majority (61%) of students tended to mark incorrect answers (three functional synapse types--51%; and five functional synapse types--10%). Further, 39% of them correctly answered the question 5. These results showed that most of the students did not master the number of the synapse concept.

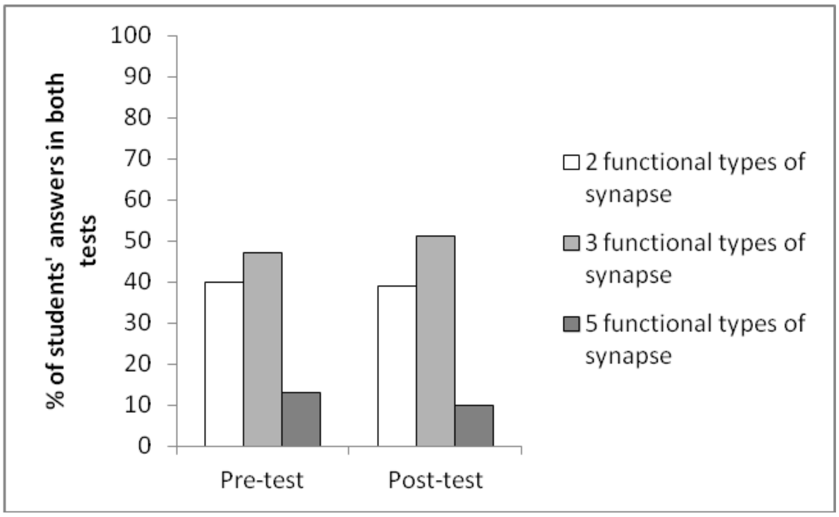

Figure 5. Percentages of the students' answers to the functional type number of the synapse.

h) The synapse pattern

For the question 6 (Q6) we asked the students to make a synapse pattern. Their responses to the pre- and post-tests indicated that over 90% of them could not give a correct pattern for the synapse (see Figure 6). That is, these students seem to have found the iconic issues problematic.

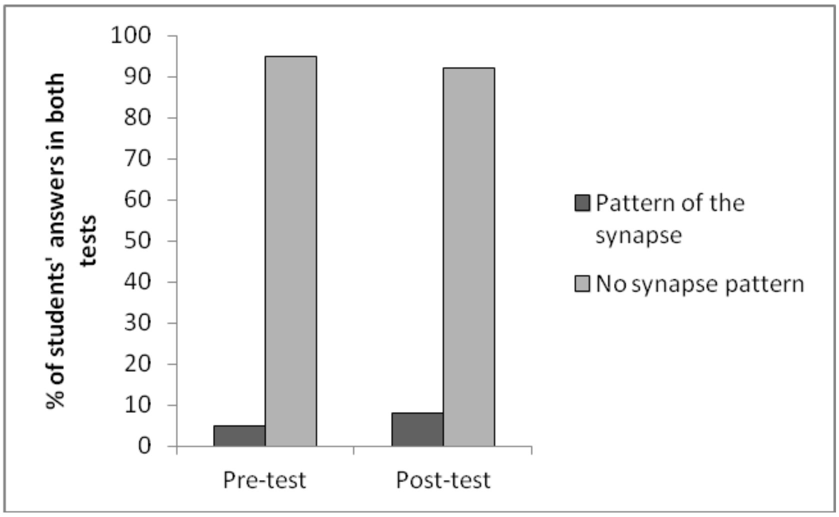

Figure 6. Percentages of the students' answers to the synapse pattern.

ı) The definition of the neuron

The question 7 (Q7) involves the neuron concept, which is a key concept of neurotransmission. The results showed that the students perceived the neuron as an uncontrolled concept. In the pre-test, only 21% of them referred to two correct definitions (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. On the other hand, 53% of them chose one of the correct definitions. In fact, 43% of them limited their responses to an anatomical description of the neuron (definition a), whilst only 10% of them dealt with the functionalities of the neuron (definition c). The rest of them (26%) marked the incorrect definition (the neuron is the only cell that constitutes our brain--definition b).

The results of the post-test revealed an increase in the percentages of the correct answers (see Figure 7). But this increase was not enough, since the percentages of the students, who gave the correct definition of the neuron (definitions a+c), did not exceed 32%. Indeed, two-third of them did not fully understand the concept of neuron. The fact that half of them opted one correct definition (definitions a or c) means that their answers still remained incomplete. Also, the fact that 18% of them selected the incorrect definition (definition b) showed that these students were unable to achieve a level of conceptualization allowing them to acquire the neuron concept.

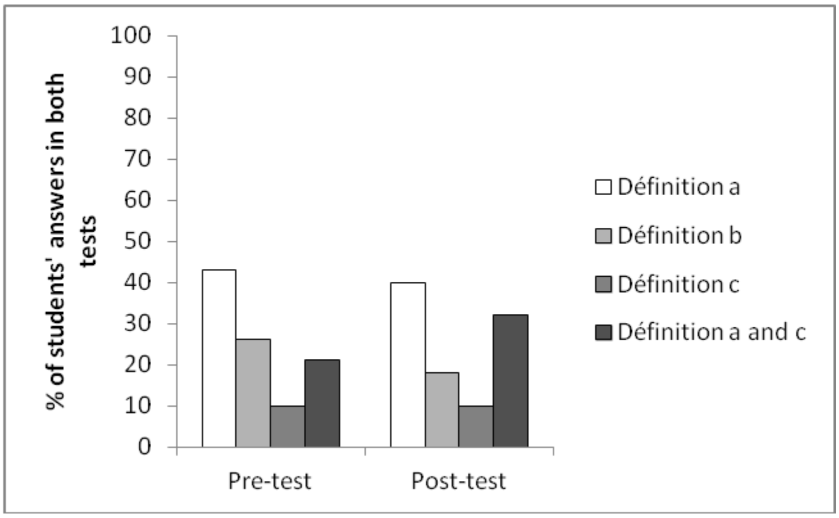

Figure 7. Percentages of the students' answers to the neuron definition.

i) The neuron pattern

As seen from Figure 8, their responses to the question 8 (Q8) which is about the neuron pattern) showed that the students did not really conceptualize the neuron concept. The percentages of the students, who were unable to give the neuron pattern, were 69 for the pre-test and 82 for the post-test.

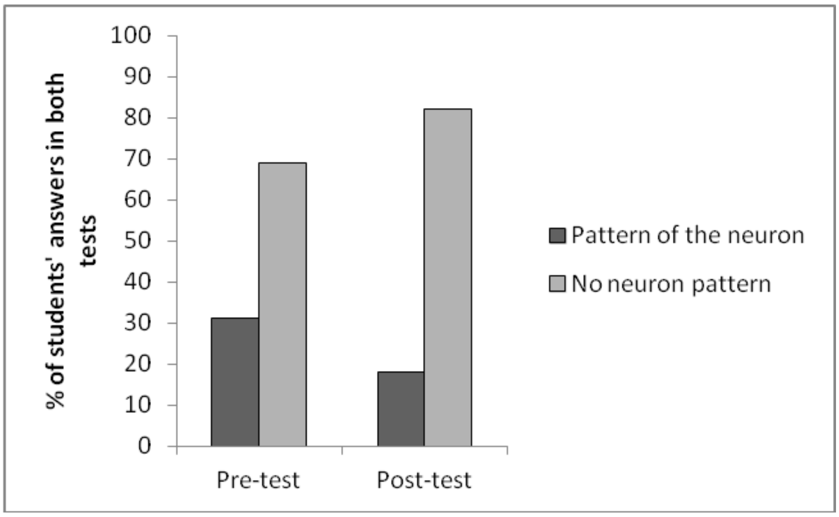

Figure 8. Percentages of the students' answers to the neuron pattern.

j) The definition of the neurotransmitter

The question 9 (Q9), which is an open-ended question, students were asked to define the concept of the neurotransmitter. To analyze their responses to the question 9, we based on identified a set of key words defining the concept of the neurotransmitter (chemical substance, transmits the information, synthesized by a neuron).

As observed in Figure 9, the results obtained on the upstream phase of the neurotransmission education indicated that 52% of the students did not propose any definition for the concept of the neurotransmitter. Further, 12% of them seemed to confuse the neurotransmitter with the neuron (i.e., the neurotransmitter is a neuron). Moreover, the percentage of the students, who formulated a correct definition, was 36%. This percentage was divided into two students categories which 8% of them defined the neurotransmitter or neuromediator as a chemical substance synthesized by a neuron in a synapse and transmits the information (nervous message) from a neuron to a cell target. Moreover, 28% of the students formulated some partial definitions, which were more or less correct with incomplete definition of the neurotransmitter concept. The percentages of some fragmented definitions, which included chemical substance, chemical substance synthesized by a neuron, information transmission from one neuron to another and cited neurotransmitters such as GABA, Acetylcholine or a neuromediator are 8%, 5%, 9% and 3% respectively.

For the same question, the downstream phase results of the neurotransmission education were almost similar to the upstream ones. Indeed, 65% of the students were unable to give a definition for the neurotransmitter, whereas 12% of them gave incorrect definitions (the neurotransmitter is a neuron--7%; and the neurotransmitter acts as a synapse--5%). As well as, the percentage of the students, who gave correct and complete answers, was about 23.

As can be seen from Figure 9, majority of the students did not assimilate the neurotransmitter concept and their conceptual growth of the concept was very minimal.

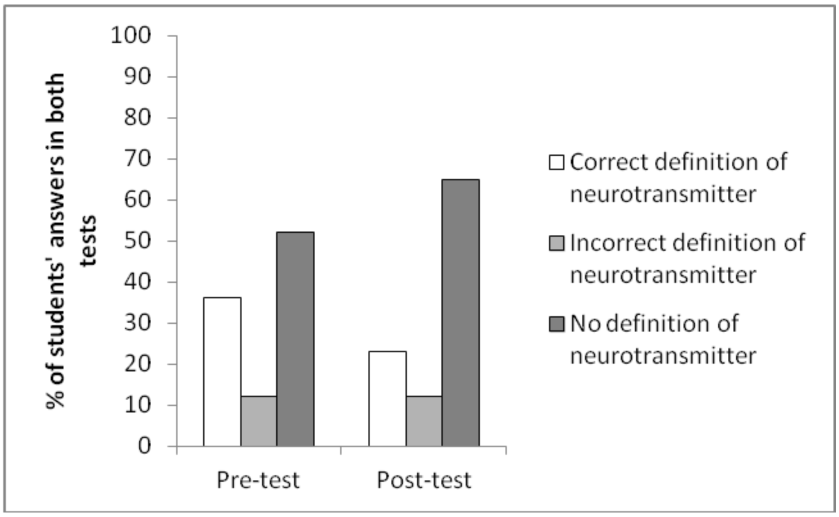

Figure 9. Percentages of the students' answers to the neurotransmitter definition

k) The definition of the neurotransmission concept

The question 10 (Q10), students were asked to define the neurotransmission concept. As seen from Figure 10, most of the students (78%) in the pre-test did not give a definition for the concept, whilst 13% of them gave an incorrect definition of the concept (defining the concept as a synapse--6%; and receiving it as a nervous message--7%). In contrast, 9% of them were able to give a correct definition of the neurotransmission concept. That is, the correct definition refers to the passage of nervous message across a synapse, which releases a neurotransmitter stored in pre-synaptic vesicles into the synaptic cleft. Thus, specific receptors present its fixation from pre-synaptic surface into post-synaptic surface.

As observed in Figure 10, 83% of the students did not define the neurotransmission concept in the post-test. 7% of them answered that the neurotransmission was a transformation of the nervous message, which is an incorrect definition. On the contrary, 10% of them were able to give the correct definition of the neurotransmission concept.

The results of their responses to the question pointed that majority of the students did not fully comprehend the neurotransmission concept after the neurotransmission education at the university.

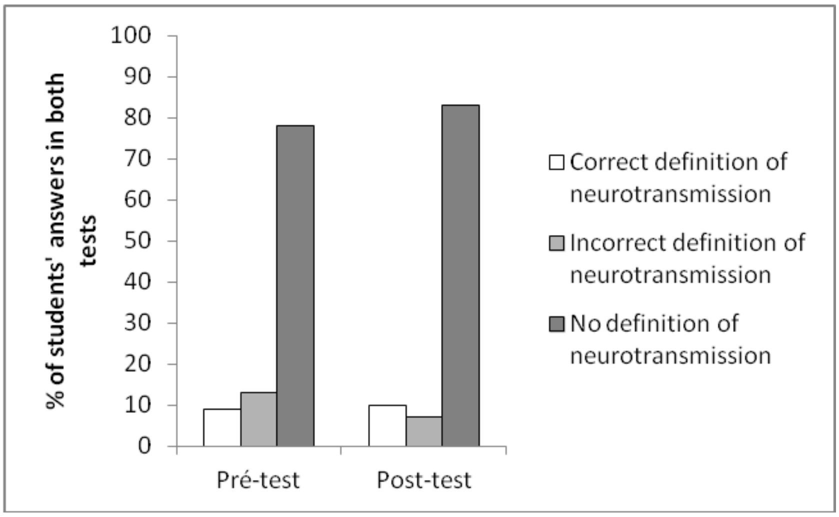

Figure 10. Percentages of the students' answers to the neurotransmission definition

DISCUSSION

The students' responses to the pre-test and post-test showed that most of the students perceived the propagation of the nervous message as a continuous (Q1) (72% in the pre-test and 62% in the post-test). Moreover, nearly half of them viewed it as an electrical nature (Q2) (42% in the pre-test and 50% in the post-test). The results highlighted the persistence of the electrical conception and its pre-acquired resistance. This may stem from the electrical model of the nervous message, which is the most detailed and treated in high school. Hence, the students seem to have not gone beyond this model. In spite of an advanced teaching on the concept, the students tended to base on their pre-conceptions of the concept treated in the high school (1st year of the Baccalaureate of Earth and Life Sciences). This result is in a harmony with Laribi et al. (2010)'s statement on the dominant feature of the electrical conception in transmitting the nervous message among students.

Their responses to the question (Q3) showed that three-quarter of the students seemed to understand the responsible structure of the nervous message transmission, namely the synapse. Furthermore, their responses to the questions (Q4, Q5 and Q7) indicated that, most of the students had deficiencies at well-assimilating two concepts (synapse and neuron) despite the fact that they had a deeper education at the university. 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 their responses to the questions 6 and 8 (Q6 and Q8) revealed that the students possessed some pitfalls at visualizing the concepts "synapse and neuron." This finding is in a harmony with Kaddari's (2005) study highlighting university students' perceptual difficulties of the atomistic iconic.

The results of the students' responses to the two open-ended questions 9 and 10 (Q9-Q10) indicated that most of the students failed to integrate chemical conception into learning of the neurotransmission concept. To define the concepts "neurotransmitter and neurotransmission," the results showed the persistence of the electrical conception.

The students' answers to the questionnaire clearly illuminated a consistency throughout all questions because majority of them asserted that the nervous message propagated within a continuous manner. This means that those students prefer using the electrical conception instead of involving the chemical one. On the other hand, this may be due to the fragmented learning way that makes these students fail to link the introduced concepts with each other (Laribi et al., 2010). This finding is in a parallel with confirmed by Sadi (2014) depicting that the students perceive genetics as a separate learning area and memorize the concepts, terms and definitions without any interlink between them. Nevertheless, the complexity of scientific knowledge (Astolfi, 1992) (e.g., the concepts "neurotransmitter and neurotransmission") may make student learning difficult.

These difficulties may hinder their learning of the neurotransmission concept and prevent their conceptual evolution/progression to build an adequate knowledge close to scientific reality. In fact, this result is very consistent with earlier studies. That is, they have reported that students' knowledge is often overestimated (Kaddari, 2005; Ozmen, 2004; Clément, 1994; Albanese & Vicentini, 1997) and pre-conceptions sometimes constitute barriers/obstacles to learning (Jonnaert, 1988; Darley, 1994; Schneider and Stern, 2010; Abraham, Perez & Price, 2014; Kampourakis, Silveira & Strasser, 2016; Luksa et al., 2016). So, it can be deduced that the students have difficulties at differentiating their conceptions from related scientific knowledge (Laribi et al., 2010). Phrased differently, it can be inferred that they pay little attention to restructuring their conceptual understanding/worldviews into a more sophisticated model (Morin, 2014).

CONCLUSION

The results of the present study show that the students' notions of the neurotransmission concept are very primitive and far from mastery. As a matter of fact, students are mostly unable to assimilate their pre-conceptions to their learning processes. Indeed, such factors as, the persistence of pre-conceptions, the dominance of misconceptions and the limited effect of the learning sequence may block their conceptual growth to properly acquire the neurotransmission concept. Furthermore, the fact that the students possessed difficulties at schematizing the related concepts reveals that the Life Sciences students' iconic competencies are poor.

The similarity between the students' pre-conceptions of the neurotransmission concept should be integrated into further learning/understanding and instructional designs. These results call further studies for explaining the origins of the related learning difficulties and obstacles. Hence, future studies should determine pedagogical tools allowing university students to acquire the neurotransmission concept. Some of these pedagogical tools are of interest in ongoing studies/projects.

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