

Vaccination and Health Education in Morocco Concept Map Survey of Students' Representations of Immune Memory

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ABSTRACT: Background: In Morocco, the National Immunization Program (NIP) is a priority for the Ministry of Health. Due to the anti-vaccines movement, the government focused on the sensibilisation of the children that are the future citizens. Immunology became a part of the 3rd year of middle school program, which has a health education perspective. This innovation poses problems to teachers.

Aim of Study: To design a didactic strategy related to the teaching of immunology (concept immune memory), it should integrate the program of the regional centers of the Professions of the Education and training, to overcome the difficulties that could be faced while teaching it to students.

Methods of Work: The target population is students in the 3rd year of middle school education.

For collecting students' conceptions: the first step is to make a questionnaire about a combination of problem-situations based on a variety of reference social practices using the notion of vaccine. The second one is to interview some of the students about immunology, and the last step is the construction of concept maps using the students' answers. These concept maps were compared to a reference concept map that had been built and validated by some inspectors and trainers of LES.

Results: The students' conceptions on Immune memory are categorized in three categories:

- First category: The Pasteur model of the disease;
- Second Category: the military-warrior model;
- Third Category : the cognitive model.

The cognitive structure for the immunology of the majority of the respondents is relatively poor compared to the concept reference map. Even if they had a course of immunology, the erroneous conceptions weren't corrected.

Conclusion: The design of a didactic strategy should be based on:

- A historical-epistemological analysis of the conceptual development of immunology;
- A presentation of the status of immunology in the Moroccan programs of the SLE in the middle school and a brief overview of the difficulties inherent in the teaching method;

- *The awareness of the teacher of the difficulties that can be faced while teaching immunology.*
- *Highlighting students' erroneous conceptions in order to correct them to reach a conceptual change.*

Keywords: Health Education, Immune Memory, History of Science, Misconceptions, Concept Map, Epistemological Barriers

Received: 2 October 2019, Revised 29 November 2019, Accepted 10 December 2019

DOI: 10.6025/jitr/2020/11/1/31-41

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1. Introduction

In Morocco, health promotion is at the center of the government's priority concerns. With the high economic cost of care for the state and the citizen in addition to the difficulties inherent in the generalization of healthcare coverage, the way forward for our country is working to improve the health for individuals by moving the nation from a focus on sickness and disease to emphasizing prevention and well-being. Therefore, the authorities are turning towards a health education and preventive measures. The saying "*prevention is better than cure*" takes on all its meaning and importance.

In this perspective, the school is an indispensable relay and the right to health necessarily passes through it.

At this level, health education plays a key role. It is an educational process where the participative dimension of the students is important. At school, the teacher, through health education, focuses on empowering students. It encourages them to explore their own attitudes and opinions, to clarify their values and those of others, to analyze the various stages of the decision-making process.

In other words, health education should aim to produce changes in students' knowledge, understanding phenomena or ways of thinking. It can influence or clarify values, determine changes in attitudes or beliefs, facilitate the acquisition of skills and produce changes in behaviors and lifestyles.

This project will be able to mobilize students to participate in the establishment of a philosophy of prevention based on responsibility, deliberate choice and informed awareness. It enables them to acquire concepts and cognitive, methodological and emotional tools to understand current health problems and to undertake reasoned behaviors towards them.

In this context, the immunology course in Life and Earth Sciences (LES) is strongly involved in the promotion of health education because it has a scope applied in the medical field. We can mention at this level immunisation, among others.

The World Health Organization stated that two-thirds of humanity remain exposed to multiple infectious risks: tuberculosis, diphtheria, measles, viral hepatitis, meningitis, etc. resulting in the death of millions of children in developing countries each year, which justifies the optimization of a large vaccination program for the control of certain infectious diseases (1).

In Morocco, the National Immunization Program (NIP) is a priority component of the Ministry of Health, whose main mission is to reduce infant and child morbidity and mortality due to the target diseases of vaccination, which is playing an important role to see the country's progress towards achieving the third Sustainable Development Goal (SDG 3: access to health). It should be noted that vaccination in Morocco is offered free of charge to the target population in all basic health care facilities that provide vaccination to 97% of the population targeted by the NIP(2).

However, several diseases seem to have disappeared from the earth's surface, some pathologies have begun a strong comeback in recent years. Among the main perpetrators pointed out by the health authorities, there are anti-vaccination movements.

The WHO has warned of the outbreak of measles in the world with a jump of about 50% of cases reported in 2016 compared to 2015, making 136,000 deaths, pointing out that the anti-vaccination movement is a serious threat to global health(3).

In many countries, part of the population is wary of vaccines. According to some, they would be ineffective, highly risky, and would only serve the interests of pharmaceutical companies. Words that others consider irresponsible, if not criminal: attacking immunization would be to deny progress to plunge into obscurantism (4).

Nourished by a distrust of the medical community, a number of social network users, through Morocco and around the world, especially after all that is said about vaccines. Anti-vaccines “are no longer a small group, but a well-organized movement that must be opposed head-on.”(5).

The provision of immunology courses in the awareness of children, citizens of tomorrow, the importance of vaccination in the eradication of certain infectious diseases is highly relevant.

Taking in consideration the complexity and the passionate nature attached to the topic of vaccinations in an immunology course, this discrepancy observed between opinions and practices lends itself to a study based on the conceptions of the students of the 3rd Moroccan middle school concerning the notion of the vaccine (6).

In the Moroccan education system, immunology is introduced into the curricula of the LES of the 3rd year of the middle school at the time of the redesign of the curricula launched in 2003-2004 and completed in 2005-2006 (7). Having experienced a scientific revolution, the field of immunology poses problems for teachers, since it is part of the new programs in a health education perspective.

In this context, the general objective of our research is to design a didactic strategy related to the teaching of immunology in the third year to integrate in the pre-service or in-service training of middle school teachers at the Regional Centers of the Professions of the Education and Training (RCPET). Which must guide them to help their students overcome learning difficulties in immunology (8).

In this respect, the following constructivist hypothesis seems promising to us: a large part of the learning difficulties, of scientific content, results from the empiricist perspective of science teaching. The student is wrongly considered as a passive receiver whose mind is a tabula rasa where the teacher comes to print his knowledge pre-organized and pre-established in an adult logic (9).

In this article, we will focus in the first point on the spontaneous conceptions that the learners convey about the notion of vaccine in relation to the concept of immune memory by the use of concept maps. This objective boils down to discover students' cognitive structures of the third year of middle school, after a formal education in immunology, related to the concept of immune memory.

The use of concept maps (10) is justified by the fact that the learner conceptions are structures that underlie any process of knowledge construction. They also constitute an explanatory model, a grid of analysis of the reality that is offered to the knowing subject. Therefore, the way the individual will interpret the reality that is exhibited to him to be able to integrate new information to his mental structures would be largely influenced by these underlying cognitive configurations.

The concept mapping technique is about to become an essential paradigm for research in science didactics (11). Concept maps is based on the assimilation theory of meaningful learning created by David Ausubel in 1963(12). It consists of identifying the structural organization, by reference to the notion of semantic network, of the nature of representations about a given concept.

However, a constructivist approach to learning should not be limited exclusively to updating learners' conceptions of a particular scientific content. First, it is necessary to specify the type of epistemological barriers (13) that these erroneous conceptions can induce. In other words, what are the obstacles to the learning of a knowledge that could be caused by these misconceptions?

Once this in mind, the second point, will be about the identification of the conceptions, which may possibly constitute obstacles to the appropriation of the notions of vaccine and immune memory.

Keep in consideration that the concept of immune memory is a complex concept that pre-scientific roots anchored, justifying the persistence of a number of obstacles. In this logic, a study of the history of immunology (14) seems relevant and even indispensable. This historical perspective plays an important role in the search for the erroneous conceptions of learners that

could constitute stubborn obstacles to the appropriation of formal knowledge in immunology. A relevant framework of analysis to which we can relate and situate students' productions and formulations in order to understand their complexity and make sense of them.

The third part will be devoted to the results of the research. In the fourth point, we are going to suggest a teaching-learning strategy formulated from teaching-learning situations that invest students' erroneous conceptions of the concept of immune memory in order to achieve optimal learning in immunology. It is an apprenticeship could result an enrichment of the conceptual structures of the students with regard to certain notions in immunology, including the notions of vaccine and immune memory. In the fifth point, we will finish with a conclusion and a presentation of the study limits.

2. Methods of Work

- **Target Population:** Students in the 3rd year of middle school education. It is a level where there is explicit content related to immunology with a passage on vaccination. We worked with a class of 20 students. They come from families of average social level. Their age varies between 14 and 16 years old. There are as many boys as girls. They have benefited from an immunology course, which allows us to have indications on the state of integration of knowledge learned in immunology.

- **Instrument for Collecting Student Conceptions: The questionnaire** for the analysis facilities that it allows. A combinatorial of problem-situations based on a variety of reference social practices using the notion of vaccine. These problem-situations have a certain degree of complementarity and overlap in order to allow the emergence of conceptual networks relating to immune memory concept. The situations proposed to students are so complex that they require a cognitive and socio-affective mobilization of their learning in immunology.

The questionnaire has limitations for highlighting students' conceptions. Indeed, when it comes to open questions, we are left with answers that are difficult to interpret. In addition, it is difficult for students to communicate their ideas in writing. To overcome these difficulties and fill the information gap, we conducted **interviews** with six students chosen through the relevance and significance of their answers to the questionnaire. The interview protocol is flexible, inviting the interviewee to answer in a comprehensive and explicit manner to the different problem-situations to complete gaps or lack.

Data Analysis: We categorized the different student responses for each problem-situation to compare them with the reference responses. This comparison allowed us to identify kernels of meaning to serve as a basis for a categorization of students' conceptions of the immune - Memory concept. This categorization made based on the totality of the answers collected. This is a cross-sectional analysis in which all the responses collected are taken into consideration. However, this cross-sectional analysis does not allow us to account for the extraordinary diversity of responses and their uniqueness. Nor does it allow us to account for the evolution of students' conceptions of immunology and their complexity. Therefore, we used a longitudinal analysis that tracks the evolution of each respondent according to the situations considered, respecting as much as possible the meaning and the path of his thought. This longitudinal analysis is translated to the construction of each respondent's concept maps (15) based on the questionnaire and interview responses.

- **Analysis Grid:** It is constructed from the historical scan of the conceptual field of immunology which revealed to us three major stages that marked the evolution of the concept of immunity. This is a stage where a clear definition of immunity does not appear in the theoretical reflections of the authors, it is the pre-Pasteurian stage where immunity is an obscure image that does not fall under any explicit formulation (**Category 1:** the Pasteur model of the disease). A second step where a definition of immunity begins to be established corresponds to a warlike defense against microbes (**Category 2:** the military-warrior model) and a third stage, where the emphasis is on recognition and immunity, becomes the ability to discriminate the self from the non-self (**Category 3:** the cognitive model).

Development of Concept Maps:

The rules for developing the concept map can be translated into the following steps(16):

- Isolate and choose the relevant concepts;
- Prioritize them;
- Connect concepts to other by bridges.

This is a relevant way to reach our research objective of highlighting the students' conceptions of notions of immune memory. In this logic, we proceeded to the elaboration of the students' concept maps based on the corpus of their answers to the questionnaire and interview in order to have a simplified overview of the network of their conceptions. In a second step, we will compare them to a reference concept map that we have built and validated with some trainers who teach immunology.

This comparison is based on a quantification of the relevant criteria of the concept maps constructed (17).

Quantification of Data from Concept Maps: The criteria to be quantified in these concept maps are:

- The number of relevant concepts used by the respondent;
- The number of significant relationships between these concepts.

Based on these criteria, we can calculate two indices: the integrating index (Ii) and the depth index (Di).

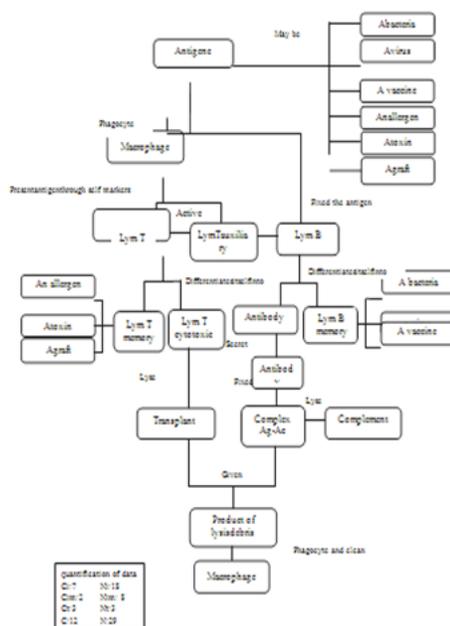
The integrating index (*Ii*) is the number of significant relations of each concept of the student's conceptual map / the number of significant relations of the same concept in concept reference map.

The depth index (*Di*) is the number of correct and relevant concepts formulated by the student / number of relevant concepts in the concept reference map.

The choice of the quantification of the data of the concept maps by integrating indices and depth is justified by the fact that the integration and the depth are two determining aspects of the cognitive structure (18). The quantification of the data of the concept map makes it possible to identify a deviation from a concept reference map. This difference may have, in certain situations, the status of barriers.

Development of a Concept Reference Map: is a concept reference map in immunology related to the level of the 3rd year of middle school education the result of research in scholarly articles, current university courses, and recent LES textbooks. However, in view of the rapid and fabulous evolution of discoveries in immunology, we have ignored the burning news in this area. We are content to develop it from a state of historical evolution of immunology that corresponds to the level of formulation of the immunity delimited by the white book (7). This concept reference map is validated with LES inspectors and trainers.

Concept reference Map in Immunology related to the Level of the 3rd year of Middle School Moroccan Education



3. Results

The construction of students' concept maps based on the corpus of their answer will allow us to have a simplified network overview of their conceptions of immune memory concept. This is at first, in a second time, we will compare them to the concept reference map. This comparison is made after a quantification of the relevant criteria of the concept maps constructed.

Conceptual Structure Relating to Immune Memory Concept

First Category: The Pasteur Model of the Disease

the vaccine is designed by students as a curative and non-preventative treatment. It is often equated with an “antibiotic”¹, a “serum”, an “antidote”, “chlorine”. In the same vein, the vaccine is conceived as a curative treatment that consists in protecting the passive and helpless body against microbial attacks. It is represented as *a drug*, an *antibiotic*, a *set of vitamins*, a *wall*.

Some students have reasoned in terms of serotherapy, for them the vaccine is a *set of antibodies*.

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Some students have reasoned in terms of serotherapy, for them the vaccine is a set of antibodies. All these formulations give the vaccine a curative character of immediate and transient effectiveness. It immediately diffuses into the bloodstream and it acts quickly. Hence the booster injections. However, although students are familiar with the booster injections used in vaccinations, they see the utility of the boosters differently. Some students think that booster shots a way to test vaccine effectiveness. Others think they are only for very dangerous diseases. In addition, for others the booster shots consist in restoring the lost strength of vaccine when fighting disease microbes.

Resistance to a second infection by the same microbe or to a poison injection is interpreted in several ways but does not refer to a dynamic resistance of the body.

Among these explanations, the familiarization or habit of the body with these microbes or poison. It is a kind of extrapolation of human feelings and behaviors to explain a biological phenomenon. These are explanations imbued with anthropomorphism. They refer to common social activities relating to human relations: familiarization and habit to a person. The familiarization model is used to explain the tolerance of a poison, an allergen during desensitization tests.

Another conception is conveyed to explain the resistance or the tolerance of a second infection or a second injection of the poison; it is the homeopathic model, which claims that the evil cures the evil. Infinitesimal quantities of poison or microbes can have tremendous healing power.

This homeopathic conception has rooted in the history of medicine. It is a philosophy and ontology therapy: evil cures evil.

Second Category: The Military-warrior Model

These conceptions draw their raw materials from the semantics of war. Indeed, students would be seduced by the semiology of combat and war. That meets their needs for war games, with all that he integrates as virtues: heroism, adventure, sacrifice, vengeance.

The vaccine is designed as a preventative treatment that involves eliciting immunity from the body; it is prepared from attenuated microbes. Vaccination is thus a kind of war fighting simulation that allows the effectors of immunity: antibodies or white blood cells to train to fight against possible microbial aggression. It is a kind of memorization of the defense strategy by antibodies or white blood cells.

As for the booster injections, they are administered so that the effectors of immunity: antibodies and white blood cells can further memorize the strategy of defense against microbes of disease prevention.

Third Category: The Cognitive Model

In this model of conceptions, the emphasis is on recognition and immunity, becomes the ability to discriminate the self from the non-self.

The strangeness character is relativized and is specified in relation to a reference, which is the self.

The conceptualization of an immune system endowed with memory is very timid. An immune system with memory analogous to that of the nervous system. This memory has an anatomical support that is found in *antibodies* or *lymphocytes*.

The conception of an immune system endowed with memory is conveyed to explain the use of booster shots in vaccinations. These are administered to ensure optimum memorization of the defense strategy.

The table 1 summarizes the major trends in conceptions of immune memory, and adherents to such trends. The results of this survey reveal that students struggle with various conceptual difficulties and adequate immunological knowledge is far from appropriate. Only two students seem to have adequate knowledge in immunology.

Major trends in conceptions	Respondent students	Number of respondent students
Category 1: the Pasteurian model of the disease	E3,E4,E7,E9,E10, E11, E12, E13, E14, E15, E16, E17, E18,E19	14/20
Category 2: the military-warrior model	E2, E5, E8, E20	4/20
Category3: the cognitive model	E1, E6	2/20

Table 1. Categories of students' conceptions of the concept of immune memory

Development of a Concept Map

We developed the students' concept maps based on the corpus of their answers to the questionnaire and interview in order to have a simplified overview of the network of their conceptions. In a second step, we will compare them to a reference concept map that we have built and validated with some trainers who teach immunology.

We counted the relevant concepts that are related to immune memory and the meaningful relationships that connect them.

- C_{im} : Number of relevant concepts related to the concept of immune memory;

- N_{im} : Number of significant relationships of the concept of immune memory.

We calculated two indices: the integrating index (I_i) and the depth index (D_i).

The table 2 summarizes the results of this quantification of the relevant concepts and the relationships that link them.

Concept/Responding students	Immune memory	
	Nim	Cim
E1	5	1
E2	3	1

E3	0	0
E4	0	0
E5	5	1
E6	6	2
E7	0	0
E8	4	1
E9	0	0
E10	0	0
E11	0	0
E12	0	0
E13	0	0
E14	0	0
E15	0	0
E16	0	0
E17	0	0
E18	0	0
E19	0	0
E20	4	1

Table 2. Results of quantification of relevant concepts and meaningful relationships of concept maps

We would like to remind you that the depth index and the integrating index give an idea of the degree of integration of a concept into a given conceptual structure. They are satisfactory if they are greater than or equal to 0.5.

The table 3 abridge the calculation results of the depth and integration indices of the 20 respondents' concept maps. The analysis of the results of the quantification of the data of the concept maps proves that the scores are very lower than 0,5 except for the pupils E1, E6 which have a $I_{dim} = 0,5$ and a $I_{iim} = 0,66$ for E1 and E6 $I_{dim} = 1$ and a $I_{iim} = 0,75$. For students E2, E5, E8, E20, the indices are equal to 0.5. It follows, therefore, that the cognitive structure for the immunology of the 18 respondents is relatively poor compared to the concept reference map.

By combining the data collected by the questionnaire, the interviews and the concept maps, we identified the main obstacles that may hinder the learning of formal knowledge in immunology (immune memory concept) in 3rd year of middle school Moroccan education.

However, it is difficult to take into account the multiple conceptions of the pupils, which are disparate and particularly idiosyncratic and which are sometimes inherent to a lack of knowledge of the basic notions in immunology.

To deal with this limitation, we will focus our attention on the conceptions that represent obstacles to the appropriation of scientific knowledge in immunology.

Analysis of Obstacles

- **Obstacle of Linear Causal Reasoning:** when students explain the manifestation of an asthma attack or the role of the vaccine, they use this kind of reasoning. we can present some examples of responses from students who demonstrate similar reasoning (*the vaccine is an antibiotic that protects the body against diseases; the vaccine is a serum that fights the disease; the allergen causes contractions of the muscles of the bronchioles*);

- **Anthropomorphic Obstacles:** Student, about the explanation of certain immunological phenomena, use expressions that reflect

Concept/Responding students	Idim	Iim
E1	0,5	0,66
E2	0,5	0,37
E3	0	0
E4	0	0
E5	0,5	0,62
E6	1	0,75
E7	0	0
E8	0,5	0,5
E9	0	0
E10	0	0
E11	0	0
E12	0	0
E13	0	0
E14	0	0
E15	0	0
E16	0	0
E17	0	0
E18	0	0
E19	0	0
E20	0,5	0,5

Table 3. Integration and depth indices derived from concept maps

human behavior: familiarization, the semantics of war;

- **Obstacle of Thinking by Categories:** it is a thought that draws its substratum from Manichean thought that opposes in an absolute and abrupt way the good and the evil.

- **Cultural Obstacle:** An obstacle finds its roots in our culture and is expressed in the following way: evil cures evil, the homeopathic model.

4. Discussion

The immunology course in Life and Earth Sciences (LES) is strongly involved in the promotion of health education because it has a scope applied in the medical field. It makes students aware of the importance of vaccination in the eradication of certain infectious diseases is highly relevant (19). This discrepancy observed between opinions and practices lends itself to a study based on the conceptions of the students of the 3rd Moroccan middle school concerning the notion of the vaccine. There can be many misconceptions for fear of or opposition to vaccination.

In addition, they must be made aware of the limits of vaccination as a delicate medical act that is at the confluence of several risks: that of the disease, that of vaccine complications and that of vaccination failures. Indeed, vaccination is a technique based

primarily on empirical work based on the observation that natural infection confers immunity that protects against reinfection. However, all infections do not have this characteristic, such as AIDS, malaria and influenza, which reduces the risk of excessive abuse of the vaccine, as a medical technique, and pushes the reflection towards a better intelligibility of the immune system and the understanding of its dynamic and highly complex interactions.

In a constructivist approach to learning, the consideration of students' conceptions of a particular conceptual field is crucial. Indeed, the study of the content of misconceptions made by the learners with regard to notion of vaccine related to immune memory concept, allowed us to rediscover the relevance of one of the propositions of constructivism, namely that any educational practice cannot save the spontaneous knowledge of learners, on the contrary, it is necessary to deal with.

Students design the vaccine as a curative and non-preventative treatment. All these formulations give the vaccine a curative character of immediate and transient effectiveness.

We can say that the immunology course in 3rd year of middle school Moroccan education could not allow an enrichment of the conceptual structure of the students. It did not allow a conceptual change for many students (20).

The operation of this proposition is not limited to this level, it must induce a didactic exploitation of these conceptions supposed to be obstacles. Identifying barriers that can be a critical step in designing an appropriate learning environment to catalyze appropriate appropriation of formal knowledge in immunology. The desired crossing corresponds to a possible conceptual progress for the student that results in an enrichment of his cognitive structure.

5. Conclusion

Without pretending to a systematic and exhaustive examination of the various conceptions implemented by the students to solve the proposed problem-situations and without being able to decide in a fundamentally rigorous way, it is nevertheless possible to identify two major trends of conceptions: a conception where a definition of immunity does not appear and a warlike conception of immunity. We have categorized the first tendency in the category: the Pasteurian model of the disease and the second tendency in the category: the military-warrior model.

The third category the cognitive model is very minoritary (2 students out of 20).

The vaccine is conceived as a curative treatment that consists of protecting the passive and helpless body against microbial attacks. Resistance to a second infection by the same microbe, to a poison injection is interpreted in several ways but do not refer to a dynamic resistance of the body. Several models are carried, that of familiarization or the homeopathic model.

Despite the fact that students have benefited from a course in immunology, that the cognitive structure for the immunology of the nine respondents is relatively poor compared to the concept reference map.

Organizing and facilitating learning situations in immunology means having the necessary professional skills based on a reference didactic knowledge of SLE adapted to immunology defined by the following components:

- A historical-epistemological analysis of the conceptual development of immunology;
- A presentation of the status of immunology in the Moroccan programs of the SLE in the middle school and a brief overview of the difficulties inherent in the teaching thereof;
- Highlighting students' representations of the notion of immunity with a focus on those that represent obstacles that could hamper the conceptualization of immunology among Moroccan students.

References

- [1] The World Health Organization. (2018). Vaccine safety communication in the digital age. 2018 Meeting report 4-5 June 2018.
- [2] The Moroccan Ministry of Health. (2013). National Immunization Program. 2013.

- [3] Larson, H.J., De Figueiredo, A., Xiaohong, Z., Schulz, W.S., Verger, P., Johnston, L.G. al. (2016). The State of Vaccine Confidence 2016: Global Insights Through a 67-Country Survey. *EBio Medicine*, Volume 12, 295 – 301. 2016. DOI: <https://doi.org/10.1016/j.ebiom.2016.08.042>.
- [4] Salvadori, F., Vignaud, L.H. *Antivax*. (2019). La résistance aux vaccins du VIII^e siècle à nos jours. Collections chronique. 2019. (In French).
- [5] Belmonte, E. *Anti-Vaccine*. (2017). When the problem is not just a question of resources. 2017. Available from: <https://www.elmundo.es/elmundo/2017/datos/especiales/medicamentalia/vaccines/antivaccines/> Confidence in vaccines has begun.
- [6] El Mazouni, N. (1997). Design and testing of a teaching strategy in immunology in the 9th year of basic education. Unpublished thesis. National doctorate in didactic of the Sciences of the Life and the Earth. Higher Normal School. Takadoum, Rabat. Morocco 1997.
- [7] Ministry of Education. (2002). White Book. Tome 3: Educational curricula of middle school in Morocco. 2002.
- [8] Elmazouni, N., Rihane, A., Tridane, M., Belaouad, S. (2018). Reference SLE didactics framework proposal for Moroccan middle school teachers Immunology as a model. *IJEP. International Journal. Engineering pedagogy* 5. 2018. PP. 74-88. <https://doi.org/10.3991/ijep.v8i5.8830>.
- [9] Kumanda, B., Ateskan, A., Lane, J. (2018). Misconceptions in biology: a meta-synthesis study of research, 2000–2014, *Journal of Biological Education*. 2018. DOI: [10.1080/00219266.2018.1490798](https://doi.org/10.1080/00219266.2018.1490798).
- [10] Novak, J.D., Cañas, A.J. (2006).. Theoretical Origins of Concept Maps, How to Construct Them and Uses in Education. *Reflecting Education*, Vol. 3(1), (2006). (On-line Journal at: <http://www.reflectingeducation.net/index.php/reflecting>).
- [11] Daley, B.J., Morgan, S., S Beman Black, S. (2016). Concept Maps in Nursing Education: A Historical Literature Review and Research Directions. 2016. Available from <https://www.healio.com/nursing/journals/jne/2016-11-55-11/%7B9ba7ecd6-855f-4532-b991-944249d79b5a%7D/concept-maps-in-nursing-education-a-historical-literature-review-and-research-directions.pdf>.
- [12] Ausebel, D. P. (1963). Meaningful verbal learning: an introduction to school learning. New York. Grune Stratton. 1963. 255 Pages.
- [13] Bachelard, G. (1989). *La formation de l'esprit scientifique*. Paris, vrin. (1989) (in French).
- [14] Moulin, A.M. (1991). *Le dernier langage de la médecine : histoire de l'immunologie de Pasteur au SIDA*. Paris, P.U.F. 1991. (In French).
- [15] Simone C.O. Conceição, S. C. O., Samuel, A., Biniecki, S.M.Y., Carter, J. (Reviewing Editor). (2017). Using concept mapping as a tool for conducting research: An analysis of three approaches, *Cogent Social*. 2017. Sciences, 3:1, DOI : [10.1080/23311886.2017.1404753](https://doi.org/10.1080/23311886.2017.1404753).
- [16] Jacobi, D., Boquillon, M. (1994). Les représentations spatiales de concepts scientifiques : inventaire et diversité. *Didaskalia* No 5, 11-23. 1994. (in French).
- [17] Joseph, D., Novak, D., Bob Gowin Gerard T. Johansen. (1983). The use of concept mapping and knowledge veemapping with junior high school science students. *Science Education*, 67 (5), 625-645. 1983.
- [18] Mason, C. L. (1992). Concept mapping: a tool to develop reflective science instruction. *Science éducation*, 76 (1) 51-63. 1992.
- [19] Najdat Shukur, M. (2012). Rate of Vaccination of Children at Diyala Province & the Effect of Parental Education on Vaccination Status, Hospital Based Study. *Diyala Journal of Medicine*. 3 (1) October 2012.
- [20] Nadelson, L. S., Heddy, B. C, Jones, S., Taasobshirazi, G., Johnson, M. (2018). Conceptual Change in Science Teaching and Learning: Introducing the Dynamic Model of Conceptual Change. *International Journal of Educational Psychology*, 7 (2) 151-195. 2018. Doi: [10.17583/ijep.2018.3349](https://doi.org/10.17583/ijep.2018.3349).