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Development of alternative teaching materials for Life and Earth Sciences: Immunology as an example

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ABSTRACT

The school textbook is an essential element in the teaching-learning process. It represents a pedagogical support for the teacher as well as for the student. However, a survey conducted by our team among a sample of students in the third year of secondary school showed that the majority do not use the textbook as a pedagogical support for the acquisition of knowledge in Life and Earth Sciences (LES).

An analytical study of the LES textbooks of the third year of Moroccan secondary school showed that these materials suffer from several shortcomings: cognitive errors, ambiguous vocabulary, and a mosaic of content that makes them difficult to use.

In order to enhance the value of the textbook and facilitate its use by students, this article proposes an alternative document that will present a life and health sciences course designed according to a rethought pedagogical scenario, with a dominant participative style, guides for the exploitation of documents, functional diagrams, summary conclusions, etc.

In order to evaluate the relevance of this project, the present work proposes, as a pilot sequence, the one relating to the mechanisms of specific immunity in the chapter "Immune responses". This article attempts to evaluate the acquisition of knowledge related to this theme, in an autonomous work session, by two groups of baccalaureate laureates of the Physical Sciences option who have the textbooks, "Al jadid fi SVT" or "Fi rihab SVT", as pedagogical supports. In a second phase, each group was divided into two sub-groups. The first was asked to use a different textbook. The second subgroup was asked to use the new personal production, relating to the same chapter, consisting of a document presenting the restructured course, illustrated by synthetic diagrams, cognitive assessments and summaries.

The results of the evaluation carried out at the end of this experiment showed that the grades of the students in the second subgroups improved significantly, compared to the control subgroups. These promising results, demonstrated here, represent a motivation to continue the work on this project of revaluing school textbooks so that they can regain their privileged place in the Moroccan educational system.

Keywords: Textbook, Life and Earth Sciences (LES), Immunology, Specific immunity.

1- INTRODUCTION

Textbooks embody one of the forms of contact between the student and science. It is seen as a stage in didactic transposition, providing information on an intermediary between the official prescription and the actual practices of teachers (Bruillard, 2005). The school textbook is a key player in didactic transposition (Grosbois et al., 1991; Perrenour, 1998; Savaton, 2005; Widemann et al., 2008), and is the essential vehicle for updating reforms and programmes (Unesco 2002).

In addition, the content analysis of textbooks could be of great importance in studying the complex interactions between science and ideology (Clément, 2004). They also represent a means for the analysis of values and beliefs in society (El Ayadi, 2000).

On the other hand, despite the great importance attached to the production of textbooks, their pedagogical design and scientific content have often been criticized. Several studies of textbooks have concluded that their mosaic content makes them difficult for students to use (Borne, 2000). In addition, these books have been the subject of numerous epistemological criticisms that point to an oversimplification of content, poorly explained and sometimes erroneous scientific concepts (Magneron, 2005).

In Morocco, the education and training system has undergone numerous reforms since 1975. The last curricular reform, in 2002, had as its main objective the adoption of the competency-based approach in the curricula and the revaluation of school textbooks.

However, a survey conducted by our team among a sample of 76 students in the third year of secondary school, spread over 7 high schools and two delegations in the north of Morocco (Tetouan delegation and M'diq-Fnideq delegation), showed that more than 88% do not use the textbook as a pedagogical support for the acquisition of knowledge in Life and Earth Sciences (LES).

Analytical studies of Moroccan LES textbooks have shown the predominance of the informative style over other styles (Selmaoui et al., 2009). On the other hand, their scientific content is marked by cognitive errors, ambiguous vocabulary, dogmatism and depersonalisation of knowledge... (Aidoun et al., 2016).

Textbooks are beginning to lose their privileged place as an indispensable link in the education system. Would a new conception of textbooks be sufficient to restore their value?

2- Research methodology

With the aim of restoring the value of the textbook and facilitating its use by pupils, this article proposes an alternative document which will present a LES course designed according to a new pedagogical scenario, with a dominance of the participative style, guides for exploiting the documents, functional diagrams, summary conclusions, etc. (See examples in the appendix)

To evaluate the relevance of this project, a pilot sequence was chosen; it is the part relating to the mechanisms of specific immunity, pertaining to the chapter "Immune responses" of the program of the second year of the Baccalaureate, option LES.

2.1- Choice of theme

2.1.1- Why Immunology?

Unlike most traditional biological disciplines, which are defined by a specific level of analysis (organism, cell, molecule), Immunology is distinguished by its "transversal" character. Immunological concepts call upon most of the other biological sciences, of which they constitute a real crossroads: organic chemistry, biochemistry, anatomy, physiology, genetics and even ecology.

On the other hand, Immunology suffers from a major communication handicap due to a totally incoherent nomenclature requiring particularly difficult memorisation efforts (Revillard, 1997).

In addition, the use of certain common terms in Immunology (cooperation, memory, recognition, presentation...) could have interferences, sometimes harmful, with the common language.

Such peculiarities could represent an obstacle to the learning of Immunology by the students. In order to verify the validity of this hypothesis, the marks of continuous tests in LES of a random group of students were collected and analysed. The sample consisted of 212 students of the 3rd year of secondary education, LES option, distributed over 5 high schools of 3 delegations, belonging to 2 Regional Academies of Morocco (Fez-Boulemane and Tangier-Tetouan), during the school year 2015-2016.

This analytical study showed that the lowest marks, obtained by the students of our sample, were in continuous control of Immunology (Aidoun, 2019).

2.1.2- Why Specific Immunity?

This choice is justified by several points:

- The place attributed to this paragraph in the textbooks: the mechanisms of specific immunity occupy almost 29% of the volume devoted to immunology;
- The great importance of the mechanisms of specific immunity in the course of the immune response;
- The importance attributed to these concepts in the curriculum: one finds thus that out of the 29 hours devoted to the immunology course (not including evaluations), 12 hours are preserved for specific immunity, which represents more than 41% of the time attributed to this chapter;
- The privileged place that the mechanisms of specific immunity occupy in the subjects of the national baccalaureate examinations: a statistical study concerning the subjects of the national examination in LES, from the 2007/2008 school year to the 2014/2015 school year, showed that the questions relating to this paragraph represent 89% of all the immunology exercises in the subjects of the normal sessions and 59% for the catch-up sessions...(Aidoun, 2019)
- The importance attributed to it in the subjects of the entrance examinations to medical and pharmaceutical studies. For example, an analytical study of the subjects of the Faculties of General Medicine and Dental Medicine in Rabat, since 2003, has shown that questions relating to specific Immunology represent 66% and 68% of all questions in Immunology respectively (Aidoun, 2019).

2.2- Conduct of the experiment

In order to evaluate the relevance of the new production, with a view to autonomous use of the textbook, the experiment was carried out with a group of 16 volunteer baccalaureate students in the Life and Earth Sciences option. This experimental study took place over two periods of two sessions each. Each session lasted two hours.

In the first period, the students were divided into two groups. The first group (8 students) worked with the textbook "Fi Rihab SVT" and the second group (8 students) used the textbook "Al jadid Fi SVT" as a teaching aid. This period ended with a half-hour evaluation.

In the second period, 5 elements of each group used our personal document as a teaching aid for learning. While the others were asked to use a different textbook from the one used in the first period (see table). This self-training was followed by a second evaluation.

Table 1: Distribution of pupils during the experiment.

Groups	Group 1		Group 2	
	Subgroup 1-a (3 students)	Subgroup 1-b (5 students)	Subgroup 2-a (3 students)	Subgroup 2-b (5 students)
1st Période (2 sessions of 2 hours)	Textbook « Fi rihab »		Textbook « Al jadid »	
	Evaluation 1 (obtaining a first mark = mark 1)			
2^d Période (2 sessions of 2 hours)	Textbook « Al jadid »	Document	Textbook « Fi rihab »	Document
	Evaluation 2 (obtaining a second mark = mark 2)			

3- Analysis of the results

In order to respect the criteria of objectivity, all the papers were corrected anonymously. The scores of the two assessments obtained by the students in each group are presented in Figures 1 and 2.

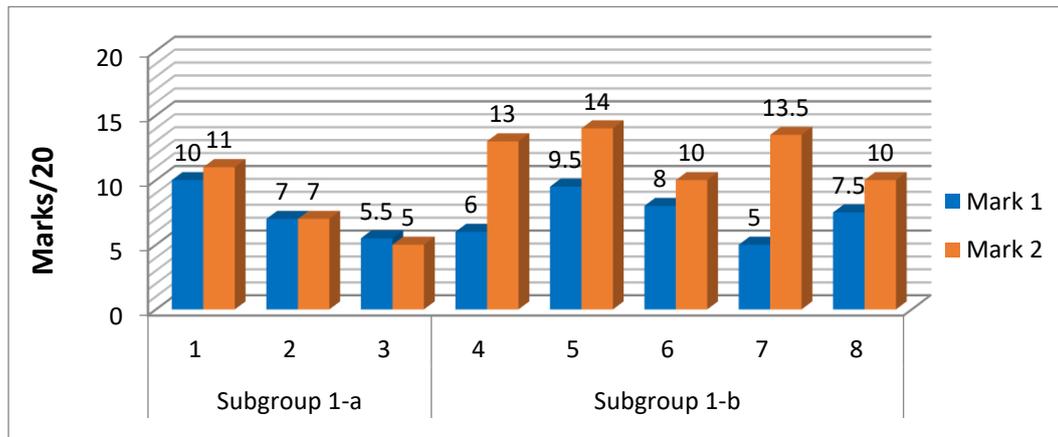


Figure 1: Results for students in the first group.

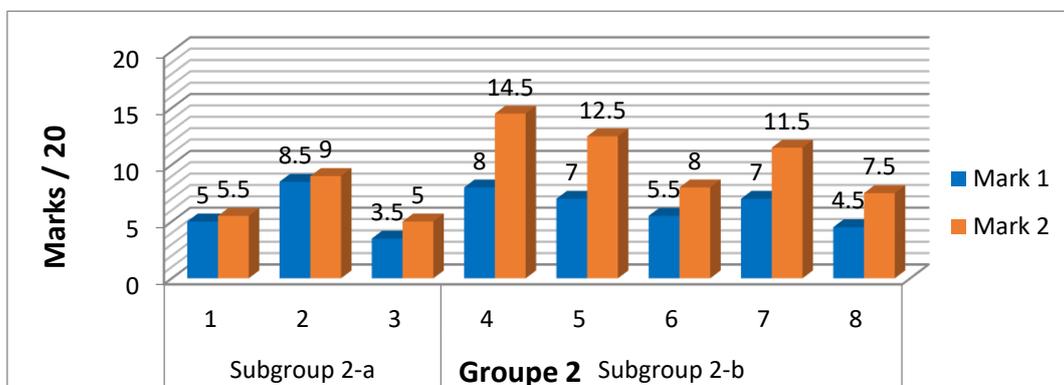


Figure 2: Results for students in the second group.

To analyse the results, two statistical hypotheses were formulated:

- The null hypothesis or Ho: assumes that there is no significant improvement in students' grades after using the document.
- The alternative hypothesis or H1: postulates that there is a significant improvement in students' marks after the use of the document. This is a one-way alternative hypothesis.

In order to test the validity of these hypotheses, the grades obtained were subjected to a t-test, where the p-value (or Sig.) allows the alternative hypothesis (H1) to be confirmed or refuted:

- If the p-value is greater than 0.05, the null hypothesis (H0) should be accepted and it should be concluded that there is no significant difference between the scores of the two tests;
- If the p-value is less than 0.05, the null hypothesis should be rejected and it should be concluded that there is a significant difference between the scores of the two tests.

Table 2: Statistics for matched samples (Subgroup 1-a)					
		Average	N	Standard deviation	Mean standard error
Pair 1	Test 1	7,5000	3	2,29129	1,32288
	Test 2	7,6667	3	3,05505	1,76383

Table 3: Paired samples test (Subgroup 1-a)									
		Paired differences					t	ddl	Sig. (bilateral)
		Average	Standard deviation	Mean standard error	confidence interval 95% of the difference				
					Inferior	Superior			
Pair 1	Test 1 - Test 2	-0,16667	0,76376	0,44096	-2,06396	1,73062	-0,378	2	0,742

Table 4: Statistics for matched samples (Subgroup 2-a)					
		Average	N	Standard deviation	Mean standard error
Pair 1	Test 1	5,6667	3	2,56580	1,48137
	Test 2	6,5000	3	2,17945	1,25831

Table 5 : Paired samples test (Subgroup 2-a)									
		Paired differences					t	ddl	Sig. (bilateral)
		Average	Standard deviation	Mean standard error	confidence interval 95% of the difference				
					Inferior	Superior			
Pair 1	Test 1 - Test 2	-0,83333	0,57735	0,33333	-2,26755	0,60088	-2,500	2	0,130

Analysis of these data indicates that the overall means (\bar{X}) of the control subgroups (1-a and 2-a) improved slightly (from 07.50/20 to 07.66/20 and from 05.66/20 to 06.50/20 respectively). However, this improvement remains statistically insignificant ($p = 0.371$ and $p = 0.065$ respectively). These data may therefore indicate that a second reading of another textbook was not sufficient to ensure a significant improvement in results.

Table 6 : Statistics for matched samples (Subgroup 1-b)					
		Average	N	Standard deviation	Mean standard error
Pair 1	Test 1	7,2000	5	1,75357	0,78422
	Test 2	11,9000	5	1,88414	0,84261

Table 7 : Paired samples test (Subgroup 1-b)

		Paired differences					t	ddl	Sig. (bilateral)
		Average	Standard deviation	Mean standard error	confidence interval 95% of the difference				
					Inferior	Superior			
Pair 1	Test 1 - Test 2	-4,70000	2,65989	1,18954	-8,00269	-1,39731	-3,951	4	0,017

Table 8 : Statistics for matched samples (Subgroup 2-b)

		Average	N	Standard deviation	Mean standard error
Pair 1	Test 1	6,4000	5	1,38744	0,62048
	Test 2	10,8000	5	2,99166	1,33791

Table 9 : Paired samples test (Subgroup 2-b)

		Paired differences					t	ddl	Sig. (bilateral)
		Average	Standard deviation	Mean standard error	confidence interval 95% of the difference				
					Inferior	Superior			
Pair 1	Test 1 - Test 2	-4,40000	1,67332	0,74833	-6,47770	-2,32230	-5,880	4	0,004

In contrast, the results for subgroups 1-b and 2-b show that there was a clear change in overall averages (\bar{X}) (from 07.20/20 to 11.90/20 and from 6.40/20 to 10.80/20 respectively). This is a significant improvement in scores ($p= 0.0085$ and $p= 0.002$ respectively). It can therefore be stated that the use of our document as a teaching aid contributed to the improvement of students' understanding. This is shown by a significant improvement in the assessment results.

The table below (Tab.10) represents a summary of the results obtained by the students of both groups.

Table 10: Summary table of statistical results for both groups.

Groups	Tests	Number (n)	Average (\bar{X})	Test-t	Value of p	<0,05 = *
1-a	Test 1	3	7,5000	-0,378	0,371	
	Test 2	3	7,6667			
2-a	Test 1	3	5,6667	-2,500	0,065	
	Test 2	3	6,5000			
1-b	Test 1	5	7,2000	-3,951	0,0085	*
	Test 2	5	11,9000			
2-b	Test 1	5	6,4000	-5,880	0,002	*
	Test 2	5	10,8000			

* = a significant difference.

4- CONCLUSION

The results of this study show that, in contrast to the textbooks available on the market, the use of the proposed new document as a teaching aid could lead to a significant improvement in the acquisition of scientific knowledge. This could be due to the new design adopted, which avoids the deficiencies often found in 'classic' textbooks (Choppin, 2000; Borne, 1998; Borne, 2000; Magneron, 2000; Bruillard, 2005).

However, the marks obtained did not exceed 14.5/20. One possible explanation could be the insufficient amount of time devoted to this study. The official instructions of the French Ministry of Education suggest an hourly volume of 12 hours for the specific immunity axis, under the supervision of a teacher. In contrast, our experiment took place in 8 hours without any intervention from the teacher.

Considering these conditions, the results obtained could be considered encouraging. They could motivate the research team to carry out work on a newly designed textbook covering the entire LES curriculum in the third year of secondary education, with the aim of providing students and teachers with alternative quality documentation, allowing for a reevaluation of school textbooks.

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L'IMMUNITÉ SPÉCIFIQUE

1- Mise en évidence de l'immunité spécifique:

a- Une immunité bien spécifique :

Emil Von Behring (prix Nobel de médecine en 1901) a fait des expériences avec les sérums d'individus malades. Il a surtout travaillé sur le bacille du tétanos et sur la bactérie responsable de diphtérie (maladie pouvant être mortelle mais devenue rare chez nous à notre époque).

Pour bien comprendre le déroulement de cette expérience, on signale que les bactéries de la diphtérie ou du tétanos sécrètent des substances toxiques dans le milieu intérieur : des **toxines**. Le traitement des toxines par divers agents (chaleur, formol...) leur fait perdre leur pouvoir pathogène tout en conservant la capacité de déclencher une réponse immunitaire, on parle d'**anatoxines**.

Expériences d'Emil Von Behring:

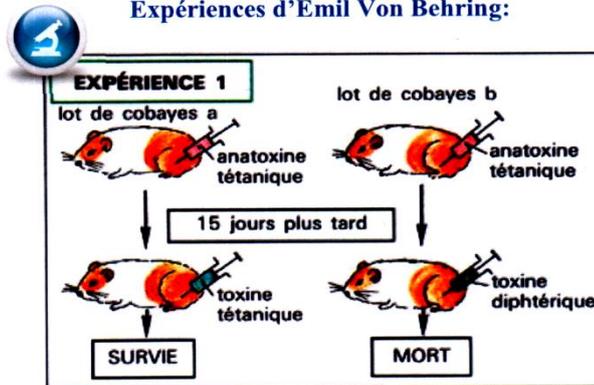


Figure 1: Mise en évidence de l'immunité spécifique.

Exploitation du document :

- 1- Comment peut-on expliquer la survie des cobayes a ?
- 2- Comment peut-on expliquer la survie des cobayes b ?
- 3- Quelle est la caractéristique de ce type d'immunité ?

Définitions :

- **Toxine** : Substance toxique élaborée par un micro-organisme et responsable de la capacité de celui-ci à provoquer une maladie.
- **Anatoxine** : Substance préparée à partir de la toxine d'un micro-organisme qui a perdu son pouvoir toxique mais conservé son pouvoir immunisant (induire une réponse immunitaire).

b- L'immunité humorale et l'immunité cellulaire : Expériences de transfert de l'immunité.

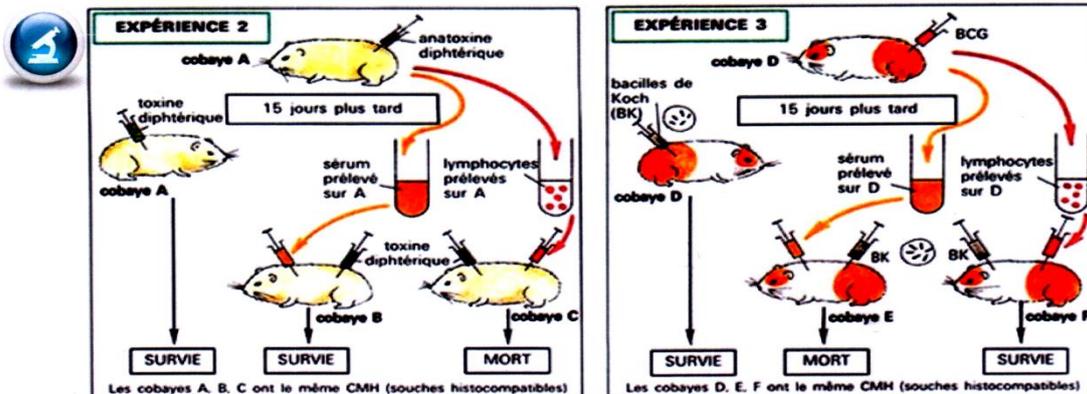


Figure 2: Mise en évidence des différents types de l'immunité spécifique.

Pour bien comprendre le déroulement de l'expérience 3, on précise que le bacille de Koch est une bactérie qui se développe à l'intérieur des cellules du poumon, mais également des os, des reins... en causant la tuberculose. A partir de cette bactérie, Calmette et Guérin ont pu obtenir des souches atténuées appelées Bacille Calmette Guérin ou BCG, qui sont à la base du vaccin utilisé actuellement contre la tuberculose.

Exploitation du document :

- 1- Comment peut-on expliquer la survie des cobayes A et D ?
- 2- Formuler des théories permettant d'expliquer la survie des cobayes B (expérience 2) et F (expérience 3).

Définitions :

- *Le sérum* : est la partie du sang débarrassé des cellules et de produits qui permettent la coagulation.
- *BCG (ou Bacille de Calmette et Guérin)* : est une bactérie non virulente pour l'homme, dérivé du bacille tuberculeux bovin et utilisée comme vaccin depuis 1921.

Conclusion :

En plus de l'immunité naturelle (non spécifique), l'organisme dispose d'une *immunité spécifique* qui est acquise après un premier contact avec un antigène. On distingue deux types de défenses immunitaires spécifiques :

- L'une est dite à **médiation cellulaire**, dont les cellules (principalement les lymphocytes) constituent l'intermédiaire fondamental ;
- L'autre est dite à **médiation humorale**, ce qui signifie que les « humeurs » (c'est-à-dire les liquides de l'organisme) constituent leur principal intermédiaire.

2- L'immunité spécifique à médiation cellulaire :

a- Lymphocytes et immunité cellulaire:

- **Types et origine des lymphocytes**

Les lymphocytes sont les acteurs principaux de l'immunité spécifique à médiation cellulaire. Afin de déterminer leurs lieux de production et de maturation, nous proposons d'analyser les expériences suivantes :