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Is the School Textbook Obsolete in the Digital Age?

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ABSTRACT

The school textbook serves as a fundamental resource for both students and teachers, playing a central role in the design of teaching-learning situations. In Morocco, due to often under-equipped biology and earth science laboratories, teachers mainly rely on textbooks as a teaching aid. However, in an era marked by technology, can it be said that the textbook is the best choice for teaching biology and earth science? The study examines teachers' perceptions of textbooks and evaluates the effectiveness of ICT as an alternative for teaching immunology, focusing on the textbook utility in biology and earth science and the comparative impact of textbooks versus ICT on student understanding. The study used a quantitative approach with 172 teachers and 63 students, employing structured questionnaires, pre-tests, and post-tests. Data were analyzed using descriptive and inferential statistics to compare the effectiveness of textbooks and ICT as teaching aids. The findings indicate a negative perception of textbooks among teachers and that ICTs as a teaching aid allow for better understanding of immunological concepts taught compared to textbooks. The study highlights the need to enhance ICT integration in science curricula in Moroccan schools and recommends updating teacher training programs to include effective ICT use strategies.

Keywords: *Textbook; ICT; learning; teaching, immunology*

INTRODUCTION

Science is an integral part of our daily lives and, as such, science education holds a fundamental place in the debate for harmonious human development (Giordan & Pellaud, 2002). In this sense, science education in our schools is crucial for developing students' essential scientific skills, including critical thinking, analytical abilities, and practical skills (Bailin, 2002). In Morocco, science education, particularly biology and earth science, begins in primary school in the form of scientific awakening and continues as an independent subject in secondary school. This education has largely focused on the use of textbooks due to the lack of teaching aids in biology and earth science laboratories (Zerhane et al., 2002, El Ouazi et al., 2019). In this context, the textbook is seen by teachers as their primary reference for teaching various scientific concepts (Conseil Supérieur de l'Éducation, 2017). Moreover, the textbook is a multifaceted tool (Lebrun, 2006). Besides being a support for knowledge to be taught, the textbook also carries a latent curriculum that reflects the values and representations present within society (Pingel, 2010). In this context, textbook authors are required to meet two types of demands: firstly, those of the curriculum direction, formulated in the pedagogical specifications that stipulate alignment with the pedagogical orientations of the discipline. Secondly, respecting social demands by transmitting the dominant culture in society without undermining its values and social representations (Khzami et al., 2012). According to Chevallard (1985), any social project of teaching and learning is dialectically constituted with the identification and designation of knowledge contents as contents to be taught (Chevallard, 1985). In the same vein, Martinand cited by Perrenoud introduced the notion of "reference practices" in 1986 to explain that during didactic transposition, one must consider both scientific knowledge and social practices (Perrenoud, 1998).

It is by responding to these various demands that the textbook plays a fundamental role in the teaching and socialization process, transmitting not only knowledge but also norms and values,

thus helping the learner to gradually find their place in their social, familial, cultural, and national context (Memaï & Rouag, 2017). However, Hutchinson & Torres (1994), earlier warned against excessive use of textbooks, emphasizing that they can lead teachers to abdicate their pedagogical responsibilities. By blindly following the proposed content, teachers risked no longer reflecting on their didactic choices and adapting teaching to the specific needs of their students (Hutchinson & Torres, 1994). Moreover, while there is no doubt about the importance of the textbook as a teaching aid, can the same be said about its effectiveness in teaching science in the digital age?

Indeed, in a world of perpetual digital evolution, where decision-makers across sectors seek to harness the best strategies to benefit from information and communication technologies (McCarthy et al., 2023), education, as a social sector par excellence, is being impacted by the advent of these technologies and is therefore undergoing unprecedented transformation. ICTs, as a support for information and as a teaching and learning environment, provide new tools for both students and teachers, enhancing learning and teaching (Das, 2019). In this context, we seek to evaluate whether the teaching of biology and earth science, based on the use of textbooks, is sufficient to achieve the pedagogical goals set for this discipline. For this purpose, this study focused on immunology, one of the most central and dynamic fields of current biological and biomedical sciences (Pradeu, 2020). Moreover, this discipline is marked by its complexity and the interdisciplinarity of its immunological concepts (Rumelhard, 1990). Nonetheless, among the goals to be achieved when studying immunology, the acquisition of rigorous scientific methodology through the application of the experimental method, which involves a well-defined itinerary from problem formulation, hypothesis development, experiment, to result interpretation (Develay, 1989). In summary, we believe that textbooks as didactic supports are outdated compared to the opportunities offered by ICTs for teaching science, particularly immunology. Moreover, we sought to answer the following sub-questions:

- What are the evaluations of teachers of biology and earth science regarding textbooks?
- How is immunology addressed in the biology and earth science textbooks?
- Can new technologies effectively complement or replace traditional textbooks?

MATERIALS AND METHODS

Research Design

To highlight the perceptions of biology and earth science teachers towards the textbook as a didactic support for teaching immunology and to examine the extent to which the textbook can compete with the rise of digital technologies that deeply modify teaching and learning methods, we conducted two studies combining qualitative and quantitative data:

- Teachers' perceptions toward textbooks;
- Comparative study of immunology teaching based solely on the textbook, ICT, and a hybrid approach.

Research Population

Teachers: A sample of 172 biology and earth science teachers was selected from a total of 243 teachers under the direction of Tétouan, representing 70.78% of the target population. The sample size was determined to follow the work of Creswell (1998), cited by Savoie-Zajc (2006), which emphasizes that sample size determination is less about strict rules and more about traditions specific to each field. For example, Creswell recommends a maximum of 10 interviews for phenomenological research and between 20 and 30 interviews for theoretical approaches (Savoie-Zajc, 2006). This study features a balanced diversity:

- 51.7% of participants are female.
- 43.6% of the teachers in the sample have more than 12 years of professional teaching experience. This representation ensures a reliable and relevant analysis of the data in the context of the study.

***Table 1**: Distribution of Teachers by Gender and Teaching Experience (years)*

	Gender		**Teaching experience (in years)**		
	♀	♂	[0 – 6]	] 6 – 12]	12<
%	51.7	48.3	29.1	27.3	43.6

Students: The sample comprised three subgroups of students from the Tétouan direction, studying in the second year of the baccalaureate, science of life and earth (SG1 = 21; SG2 = 21; SG3 = 21). Thus, our sample includes 63 students aged between 17 and 19, of which 79.36% are female. According to the data in Table 2, there were no significant differences between the three subgroups in terms of gender.

***Table 2**: Distribution of Students by Gender*

Gender						
	SG1		**SG2**		**SG3**	
	♀	♂	♀	♂	♀	♂
%	80.95	19.05	71.42	28.58	85.71	24.29

Data Collection Instruments

- **Teachers Questionnaire**: To determine the perceptions of biology and earth science teachers regarding textbooks as a didactic support for teaching immunology in secondary education, we conducted a quantitative study using an online questionnaire. This tool proved to be appropriate for quantitative data collection (Marchat, 2008). The questionnaire was structured around three main areas:
  - General information ;
  - Evaluation of textbooks;
  - Comparison with ICTs.

- **Student Tests**: Two tests were developed (pre-test and post-test) in relation to students' prior knowledge and acquisitions regarding self and non-self. The two tests consisted of six criteria aimed at assessing mastery of the concept of "self" and "non-self":

  - Knowledge of fundamental definitions related to the immune system;
  - Identification of structures involved in "non-self" recognition;
  - Understanding recognition mechanisms;
  - Analysis of the consequences of recognition errors;
  - Application of concepts to concrete situations;
  - Use of precise scientific vocabulary.

The experimentation took place over a week in February 2023 (two sessions, each lasting 4 hours, with a third session reserved for the post-test). The three subgroups had the same experienced teacher (19 years of service). For the pre-test, before teaching the concept of self and non-self, the

topic was discussed. The pre-test (anonymous) was administered to the three groups. SG1 received conventional teaching based solely on the textbook (Appendix 1). For SG2, the instruction was based on a digital support (Appendix 2). SG3 received hybrid instruction, using both the textbook and digital support. In the third session, the post-test (anonymous) was distributed to the three groups. The students were informed that the pre-test and post-test would only be used for research purposes.

Validity and Reliability Testing

- **Teachers Questionnaire**: The questionnaire underwent peer validation for content clarity. It was administered to a small sample of 7 teachers to assess question clarity and precision. Based on their feedback, some questions were reworded. For reliability, Krippendorff's alpha coefficient was used, resulting in $\alpha = 0.76$, indicating moderate agreement, which is acceptable for exploratory or preliminary research.
- **Pre-test and Post-test**: To ensure consistent testing, the same 7 teachers reviewed the tests to evaluate the clarity and precision of the questions. Based on their comments, some questions were reformulated.

Data Analysis

Quantitative and qualitative data were analyzed descriptively according to the sections of the questionnaires or grid, considering two criteria: frequency and specificity of responses. Data analysis was conducted using SPSS (IBM SPSS Statistics 28.0) and Excel (Microsoft Office Professional 2021).

RESULTS

Teachers' Perceptions of Textbooks

Immunology and Textbooks

Data from Figure 1 below reveals that a significant proportion of teachers (36.63%) find textbooks to be unusable. However, 41.28% of them consider textbooks to be somewhat usable. Only 22.09% believe that textbooks are usable for teaching immunology.

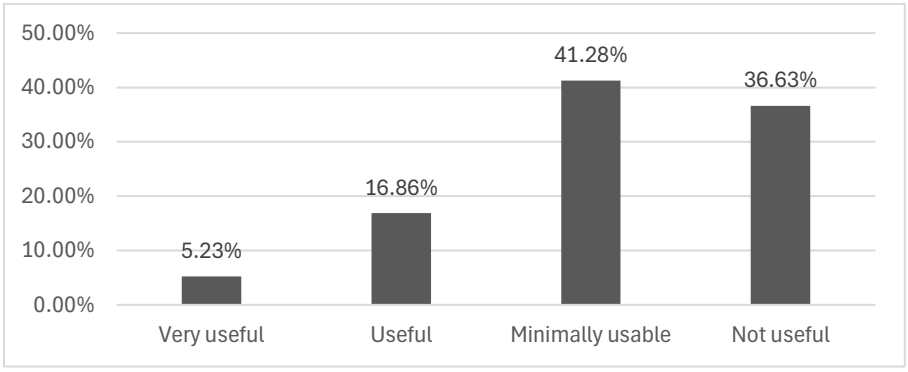

Figure 1: Teacher Perception of the Usefulness of the textbook for teaching Immunology

The results displayed in Figure 2 below show that 71.51% of our sample disagree (strongly disagree or disagree) that Immunology as presented in textbooks is well-structured and comprehensive. However, a quarter of our sample considers it to be well-structured.

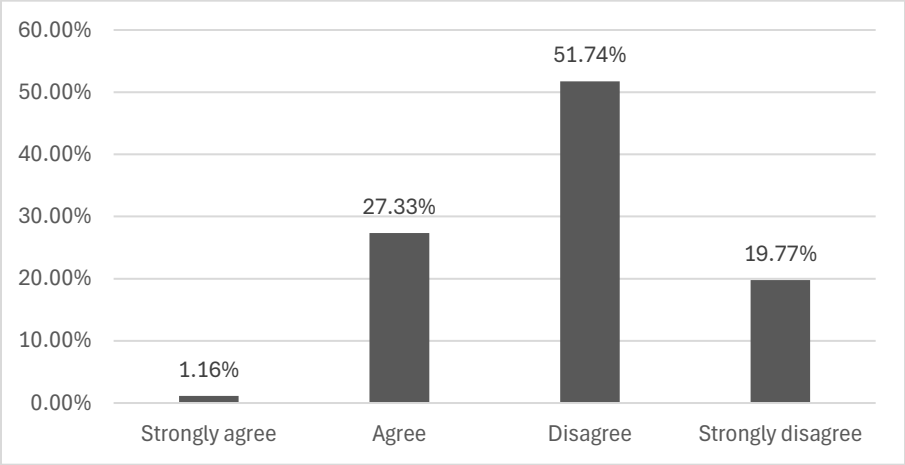

Figure 2: Immunology as presented in the textbook is well structured and complete.

The data in Figure 3 below illustrates that only 36.05% of teachers believe that textbooks are suitable for students of different levels. In contrast, 52.91% find it difficult to adapt these textbooks to the diversity of student levels. Finally, 11.05% consider textbooks to be entirely unsuitable.

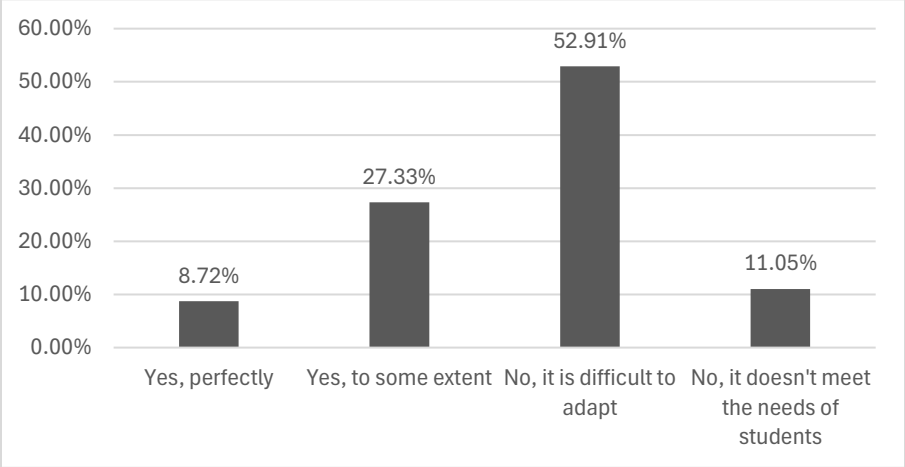

Figure 3: Adaptability of the textbook for teaching student at different levels of learning

Integrating ICTs to Overcome the Limitations of Textbooks in Immunology

According to the data in Figure 4 below, 95.35% of teachers believe that information and communication technologies (ICTs) can improve the teaching of immunology. However, a minority of 4.65% do not see the need to incorporate ICTs to enhance teaching in Immunology.

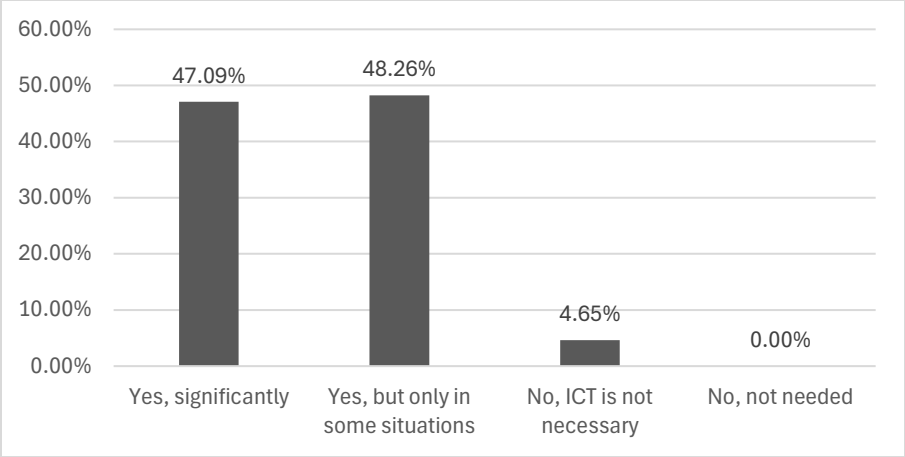

Figure 4: Perspectives on using ICT to enhance teaching immunology compared to the textbook

The data in Figure 5 highlight the limitations of textbooks when compared to ICTs, including: low interactivity (39.53%), limited capacity to customize content (25%), outdated or static information (22.67%), and restriction to a single paper format (12.79%).

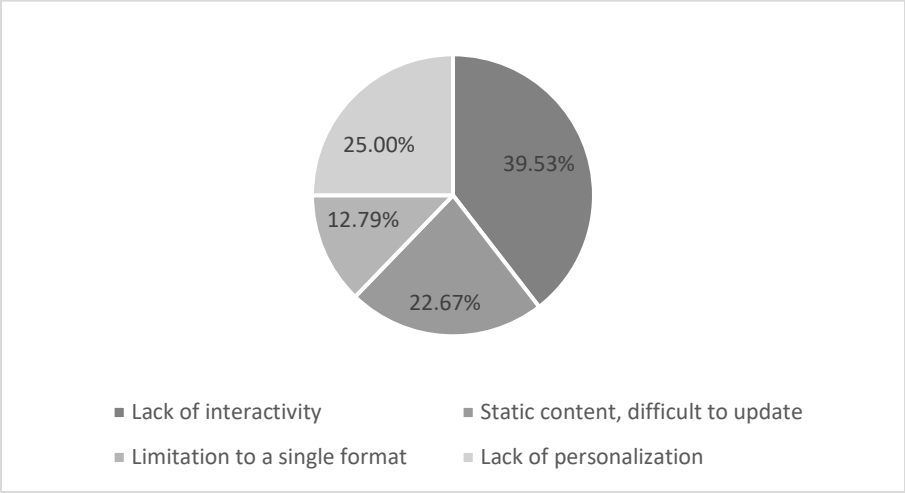

Figure 5: Aspects of textbook considered limiting compared to ICT

Students' Results from the Three Subgroups SG1, SG2, and SG3

Pre-test Results

The data in Figure 6 below shows that the immunology scores of the classes (SG1, SG2, SG3) were low. The medians were around 1.5 to 2.5 for all three groups. A strong concentration of scores was observed in the low range (between 1 and 3). However, a few atypical values, particularly in SG3, showed slightly higher scores, which may correspond to a better prior understanding among some students in this class.

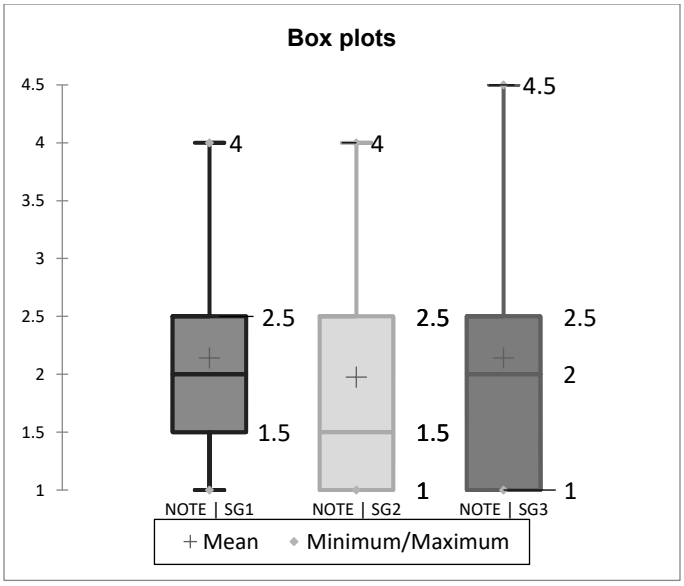

Figure 6: Students Immunology pre-test scores

Post-test Results

The data displayed in Figure 7 below reveal a significant improvement in students' immunology performances across all classes on the post-rest. The median values rose to between 5 and 7.5 across the groups, with high scores going up to 8-9. This suggests a general increase in mastery of immunological concepts among the three classes. However, this improvement was more pronounced in classes SG2 and SG3 compared to SG1.

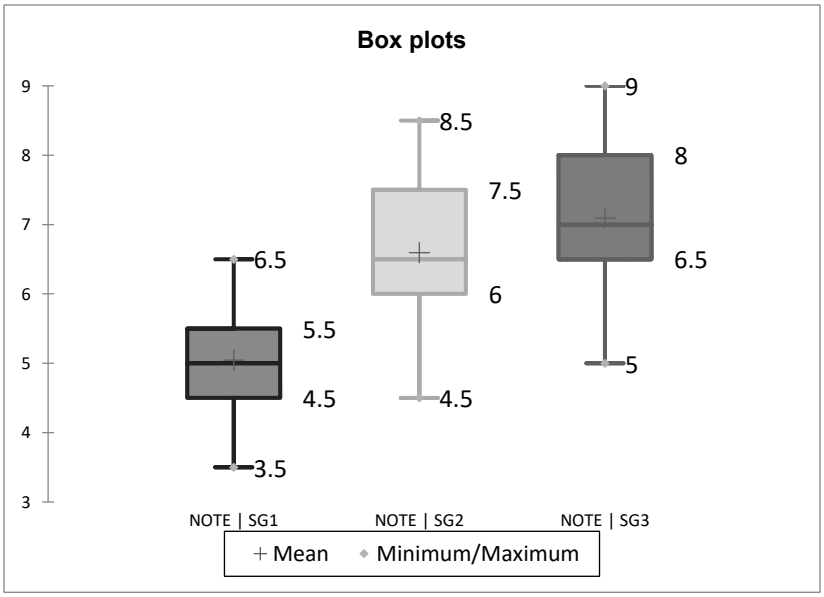

Figure 7: Improvement in students' performance in immunology after course instruction

Comparison between Pre-test and Post-test Results

Paired Samples t-Test (paired t-test)

To test the null hypothesis (H_0) that there is no difference between the means of pre-tests and post-tests, we used the t-Test. The data in Table 3 shows that SG3 had the most significant improvement in terms of average difference (+4.952), followed by SG2 (+4.619) and finally SG1 (+2.905). These results indicate that all groups benefited from the pedagogical intervention related to teaching the concepts of "self" and "non-self," but with varying levels of improvement.

Table 3: *Means of pre-tests and post-tests*

Paired Samples Statistics					
		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
SG1	Pre-Test	2.143	21	.9765	.2131
	Post-Test	5.048	21	.8047	.1756
SG2	Pre-Test	1.976	21	1.0059	.2195
	Post-Test	6.595	21	1.1025	.2406
SG3	Pre-Test	2.143	21	1.1196	.2443
	Post-Test	7.095	21	1.1025	.2406

Correlation Analysis between Pre-tests and Post-tests (Paired Samples Correlations)

The data shown in Table 4 indicate that in all cases, the correlations between pre-test and post-test scores were not statistically significant ($p > 0.05$). This suggests that the initial scores (pre-test) are not reliable predictors of post-intervention scores (post-test) in all three groups. Thus, the improvement observed between pre-tests and post-tests seems more related to the pedagogical intervention than a linear relationship between the two series of scores.

Table 4: *Correlations between pre-test and post-test scores and statistical significance (p-value)*

Paired Samples Correlation				
		N	**Correlation**	**Sig.**
SG1	Pre-Test & Post-Test	21	.293	.197
SG2	Pre-Test & Post-Test	21	-.077	.741
SG3	Pre-Test & Post-Test	21	.140	.544

A Clear Difference Between Teaching Based on Textbooks and ICTs

The results from the pre-test and post-test for students in the three subgroups show a significant difference both between the two tests and between the groups. To determine if these results can be attributed to the support used to teach the "self" and "non-self" concepts and not to a simple random effect, we subjected them to several statistical analyses.

Normality Test

To compare the results obtained by the three groups (SG1, SG2, SG3), we first checked the normality of the post-test results through two tests (Kolmogorov-Smirnov and Shapiro-Wilk). The results in Table 5 indicate that the data from the three groups SG1, SG2, and SG3 follow a normal distribution (p-value > 0.05). This means that we could proceed with parametric analyses (ANOVA) to compare the three groups, as the data meet the normality assumption.

Table 5: *Tests of Normality*

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
SG1	.143	21	.200*	.959	21	.504
SG2	.106	21	.200*	.969	21	.717
SG3	.106	21	.200*	.969	21	.717

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Comparison of the Results of the Three Groups: ANOVA Test

Data from Table 6 reveals that:

- The sum of squares between the groups is 47.865, showing that differences between the means of the three groups explain a significant portion of total variability.
- The sum of squares within the groups is 61.571, indicating that individual differences within each group explain another portion of variability.
- The F-ratio is 23.322, which is very high. This indicates that the differences between the groups are much larger than the differences within the groups.
- The p-value is 0.000, which is less than 0.05. This means that the differences observed between the means of the groups are statistically significant. In other words, there is a real difference between the groups.
- In summary, these results show that there are significant differences between the average score of the three groups and that the effect of the groups on the scores is statistically significant (F = 23.322, p < 0.001).

Table 6: *Results of ANOVA Test*

ANOVA Score					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	47.865	2	23.933	23.322	.000
Within Groups	61.571	60	1.026		
Total	109.437	62			

Multiple Comparisons (Tukey HSD)

The data in Table 7 shows a significant comparison (p < 0.05); SG2 and SG3 obtained the highest average scores, while SG1 had the lowest average scores. These results indicate that the

interventions for groups 2 and 3 had a greater impact than for SG1. Thus, groups 2 and 3 benefited from comparable improvements.

Table 7: *Multiple comparisons of the dependent variable*

Multiple Comparisons Dependent Variable: Score Tukey HSD						
(I) Class	**(J) Class**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
SG1	SG2	-1.54762*	.31262	.000	-2.2989	-.7963
	SG3	-2.04762*	.31262	.000	-2.7989	-1.2963
SG2	SG1	1.54762*	.31262	.000	.7963	2.2989
	SG3	-.50000	.31262	.254	-1.2513	.2513
SG3	SG1	2.04762*	.31262	.000	1.2963	2.7989
	SG2	.50000	.31262	.254	-.2513	1.2513

*. The mean difference is significant at the 0.05 level.

DISCUSSION

Textbooks: A Contested Tool for Teachers

In the Moroccan educational system, teachers enjoy a certain degree of freedom in choosing didactic materials, which can facilitate their work while adhering to the pedagogical guidelines of the discipline. Thus, the teacher interacts with various didactic resources that they sort, select, transform, and organize to structure the content to be taught (Gueudet & Trouche, 2010). Within this framework, the textbook is an indispensable didactic support for the teacher as it provides valuable assistance for planning lessons, managing classes, and conducting assessments (Gérard & Roegiers, 2009).

Indeed, in Morocco, due to the lack of didactic aids in the laboratories of life and earth sciences, the teaching of Immunology occurs without recourse to experiments and manipulations (El Ouazi et al., 2019). Under these conditions, teachers rely on the textbook as a teaching and learning instrument, considered one of many sources from which teachers can draw to create an effective lesson (Gak, 2011). However, for most teachers, textbooks have a rather negative appraisal for the teaching of Immunology. More than a third of them consider these textbooks unusable for effectively teaching immunology, while 41.28% deem them poorly usable. This observation aligns with their assessment of the presentation of Immunology in textbooks, as 71.51% of our sample disagreed (not agreed or strongly disagreed) that the Immunology content presented in textbooks is well-structured and comprehensive. Indeed, the results of several studies highlighted the presence of various types of inaccuracies and errors in the didactic transposition of immunological concepts in textbooks, even if learners receive lessons on Immunology. They do not mobilize immunological knowledge in acquiring health education (Aidoun et al., 2016a). Furthermore, the teaching-learning situations in our three Moroccan textbooks are not sufficiently usable for problematization activities in science, as they do not provide empirical data or questions to stimulate student reflection (Bekhat et al., 2020). Moreover, the scientific knowledge related to Immunology that should be taught to students includes a wide range of complex concepts. In this sense, Bernard (2006) highlighted the complexity of Immunology due to its structural and functional complexity (Bernard, 2006). For Thomas (2015), the complexity of the immune system resulted from its multi-scale organization, ranging from organ to molecular level (Thomas-Vaslin, 2015).

Not taking into account this complexity during the development of textbooks can explain the negative appraisal of teachers towards textbooks. In this perspective, a study on the presentation of Immunology in textbooks highlighted excessive simplification, lacking precision on certain immunological concepts. It also noted confusing language, including poorly translated scientific terms or expressions that may create confusion among learners. These elements could represent significant obstacles to learning (Aidoun et al., 2016b). Finally, even though all educational reforms in Morocco - changes in curriculum, integration of new teaching subjects, competency-based education - emphasize the importance of the learner's involvement and autonomy in their learning process (constructivist approach), textbook authors still fail to put this awareness into practice during didactic transposition of scholarly knowledge into teachable knowledge. In a similar context, a study conducted by Selmaoui examined the educational approach adopted by textbook authors and concluded that the informative and dogmatic style predominates in parts of textbooks where there should be a learner-centered teaching approach in constructing their knowledge (Selmaoui et al., 2007). Indeed, textbook authors use very little participatory styles in subjects related to environmental and health education, where learner participation and autonomy are essential. Immunological knowledge is presented as given truths and not as the result of evolving immunological theories (self and non-self theory, microbial theory, immunization theory, and lateral chain theory among others).

ICTs: A Solution to Overcome the Limitations of Textbooks

Less than 36.05% of the sample of teachers consider that textbooks are more or less suited to different student levels, while the remaining 63.95% find that textbooks are not. Indeed, textbooks provide learning situations with uniform content for the whole class, without considering differences between students. In this sense, Chartier (2003) noted that in a learning situation, each learner differs from others in their learning performance and the shape they gave to their learning (Chartier, 2003). In this context, ICTs can be an alternative to textbooks for teaching Immunology more effectively. Didactically, ICTs act as facilitators of learning by being mediators between knowledge and learners. Moreover, they play the role of organizer of learning activities, contributing to the improvement of learning (Knoerr, 2005, Lebrun, 2011). In this regard, Peraya & Peltier (2012) argued that ICTs are both teaching content and learning environments in which learners can construct and produce knowledge about these same technologies, as well as collaborate, interact, etc. (Peraya & Peltier, 2012).

Moreover, the results of our experiment revealed a significant improvement in learning the concept of self and non-self in the case of using ICTs (SG2) compared to using the textbook as a didactic support (SG1). Indeed, the students in SG2 seem to have overall better performance, with higher scores extending upwards with an average slightly above the median of 6.5/10, while for SG1 students, scores are concentrated in the lower levels with an average around 5/10. This is in line with the fact that 95.35% of the teachers in our sample believe that information and communication technologies (ICTs) can enhance the teaching of Immunology. Moreover, Karsenti & Collin (2013) and Vescio et al., (2008) indicated that ICTs improve teaching and learning by making classes more interactive and motivating, while promoting personalization and access to varied resources. They stimulate student collaboration, provide instant feedback, and develop essential digital skills; well-thought-out use of ICTs enhances student engagement and participation in classes, while also positively transforming teaching practices (Vescio et al., 2008, Karsenti & Collin, 2013, Sofi et al., 2017). In perfect alignment with this, the teachers in our sample emphasized that textbooks are limited compared to ICTs, especially due to their low interactivity, inability to personalize content, and the presentation of fixed or outdated information.

CONCLUSION

The results of this study revealed that despite textbooks being used by teachers in the life and earth sciences, they are not satisfactory as didactic tools, and this is for several reasons. Indeed, they present outdated and non-contextualized immunological content. They encourage only a limited adoption of the experimental approach; most learning situations are based on document analysis rather than experimentation and manipulation.

In this context, ICTs can prove to be a very plausible alternative to textbooks, particularly for the paper format of textbooks. This is due to the opportunities offered by the use of digital tools to enhance the teaching and learning of sciences. However, even though the results of our study indicate that textbooks alone are not enough to constitute an effective didactic support for teaching Immunology, ICTs are. This study opened the way for another alternative, that is, combining textbooks and ICTs simultaneously. This is the case of teaching in SG3, where students worked simultaneously on the textbook and ICTs, leading to better understanding of the taught immunological concepts, reflected in good grades with an average of 7.2/10, higher than the median.

In this perspective, we believe that the textbook, as a didactic support, will need to evolve from its traditional fixed-paper format presenting a single content for all students to an interactive digital textbook. This will allow it to continue to play a crucial role in knowledge acquisition by offering learners the opportunity to work on varied didactic supports and guiding them to consult bibliographical and digital resources to deepen and evaluate their learning, thus enriching their knowledge.

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