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Assessing the Adequacy of Contemporary Life and Earth Textbook in Morocco: A Case Study of Blood Glucose Regulation

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Abstract:

Blood glucose homeostasis is a fundamental concept in biology. Yet, in the Moroccan education system, it is only covered in the 11th grade. This might explain why the majority of students struggle to understand this complex notion. Fingers of blame are also pointed to textbooks and how they didactically (mis)transposed this knowledge from its academic form to its teachable one. In fact, the significance of textbooks in education is indisputable. Hence, analyzing them may provide insights on students (mis)conceptions. In this study, we aim to critically analyze the sections on blood glucose regulation in two widely-used Life and Earth Sciences textbooks in Morocco, intended for students enrolled in the experimental sciences track. To do so, the present study follows the findings and recommendations of the intriguing systematic review of literature by Vojř & Rusek (2019) which urges for the need for science textbooks research in different local contexts around the globe. In the same vein, the absence of such research in the Moroccan context makes this study an obligation. Methodologically, this study adopted Bernard et al's.,(2007) contrastive approach. According to our findings, the juxtaposition of these two textbooks reveals several shortcomings, errors, and inconsistencies. By taking the didactic transposition of blood glucose homeostasis into the heart of its exploration, this study –though rooted in its Moroccan context- advocates for a wider applicability of its findings.

Keywords: textbook research; contrastive approach; didactic transposition; science; blood glucose regulation;

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INTRODUCTION:

In the didactic transposition process –which according to Chevallard & Bosch (2014) refers to the transformations a body of knowledge undergoes from the moment it is produced, put into use, selected, and designed to be taught until it is actually taught in a given educational institution- textbooks' role cannot be neglected. They represent roadmaps for how content should be taught or learned. At all levels of schooling, textbooks are often used as the primary organizer of the subject matter that students are expected to master and provide detailed explanations of topics to be taught (Chiappetta *et al.*, 2006, 2007). Textbooks are also essential tools with which teachers help students accomplish the goals and objectives of standards and curricula (Bou Jaoude & Noureddine, 2020).

Indeed, the textbook is considered to be at the junction of the formal curriculum and the actual curriculum (Lebrun & Niclot, 2009), and plays a key role in the acquisition and transmission of knowledge (Simard, 1994). Textbooks, without question, are among the key components of any educational system; they contribute to ensuring teachers' didactic, scientific, pedagogical, and professional competence. According to UNESCO report in 2002, in developing countries such as Morocco, textbooks are regarded as major resources for teaching and primary means of educational reform and success. Also, they are the primary reference for in-class and out-of-class activities, and they play a crucial supportive role for teachers on a daily basis (Benoit, 1997) because of their capacity to facilitate learning (Audigier *et al.*, 2006). Taking all these things into consideration, textbook remains an integral part of the teaching-learning process, as indicated in figure 1.

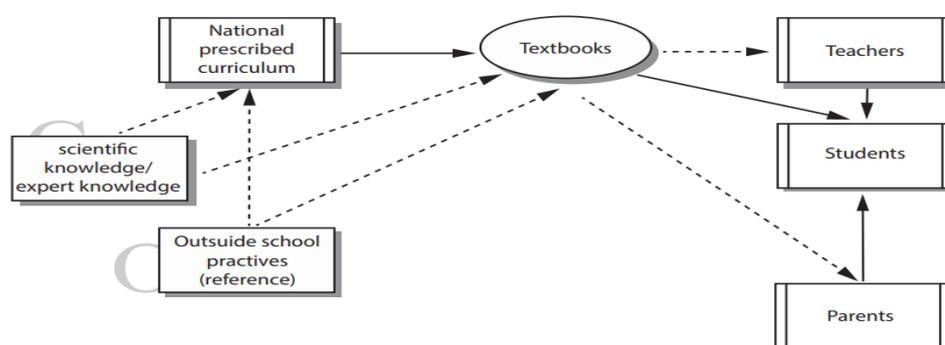


Figure1: Textbooks at the core of a process: from national programme (prescribed curriculum) to school practices (Bruillard,2011)

If we believe that science is one of the significant catalysts for development. Then, science textbooks should be designed in a way that prepares students for the twenty-first century challenges. In Morocco, continuous efforts are currently underway to enhance the quality of science education and learning. These efforts come as a response to report's findings indicating low levels of learning outcomes in Morocco, comparing to objectives of national curricula and international standards (UNESCO, 2010). Additionally, a report by the African Development Bank (AfDB) published in 2013, subsequent to the implementation of the emergency plan in Morocco between 2009-2012 (CSE, 2008), underscores that the quality of student achievements in Morocco remains subpar when compared to what is observed in other countries, both in primary and secondary education. But the question to raise here: do these efforts target the development of science curricula and textbooks? Knowing that science

textbooks should help teachers to improve their classroom practice and play better roles in enhancing scientific literacy among students. To do its job properly, textbooks should maintain high-quality standards; and the availability of such standards is one of the critical factors for the successful implementation of a curriculum reform (Liang & Cobern, 2013).

Indeed, when it comes to biology -a concrete scientific discipline that deals with complex concepts and theories- textbooks may not always provide a complete and accurate representation of fundamental biological concepts, making it challenging to fully grasp these concepts by student. Despite their evincible influence on education, research on science textbooks has not been given enough attention in Morocco. According to Boulal (2020), comparative textbook research is still a relatively unexplored area in Morocco comparing to Tunisia. In 2022, he confirms his stance again,

“Comparative research in didactics is still relatively limited in Morocco. In fact, we only have a few studies that focus on the analysis of content related to the environment in secondary school biology textbooks (Agorram et al., 2010; Hamouchi, Essafi & Hajjami, 2010; Hamouchi, 2015). Consequently, we believe it is valuable to investigate the analysis of these Moroccan textbooks, which have been understudied from a didactic perspective.”
“Boulal 2020” My own translation”

Likewise, findings of an intriguing recent study by Vojř & Rusek (2019) suggest that research in this field is surprisingly unbalanced between particular regions around the globe. In a review of 183 papers published from 2000 to 2018 in a Web of Science indexed database, the results reveal that researchers in Europe and the USA focus on textbook research more than their counterparts from elsewhere in the world. It is worth to mention that the findings reveal show that the most frequently researched textbook are those of science in secondary schools. More interestingly, biology textbooks in general dominate comparing to other natural science disciplines. The major focus of these studies is on content on the first place and learning concepts in the second place. Yet, the most surprising finding –which makes the present study more legitimate and an obligation- is the lack of any research paper on science textbooks on this particular database in Africa. To fill some of the gap in the literature, our study took upon itself to critically analyze the sections of blood glucose homeostasis in two Moroccan school textbooks in Life and Earth Sciences designed for first-year baccalaureate students (=11th grade) enrolled in the experimental sciences track. Our main focus is on content –more precisely on a particular concept- seems logical since presenting content and core concepts is the main role of textbooks

The choice of the section of blood glucose regulation in particular stems from the fact Moroccan students’ struggles to fully grasp this core concept in biology as noted by Rachidi *et al.*, (2023) which allows for understanding numerous regulatory mechanisms in physiology, as emphasized by Modell *et al.*, (2015). The importance of understanding this concept lies in its presence and interference in our daily life and health. Furthermore, considering the global epidemic of obesity and diabetes, teaching blood glucose regulation becomes a crucial requirement to prevent these diseases and share awareness in society, as highlighted by Dhouibi & Schneeberger ,(2020).

Methodology:

With the intention to improve the teaching of blood glucose homeostasis in Moroccan secondary school, this study is conducted with the aim to analyze the content of two widely used Life and Earth Sciences textbooks, namely "*Fi Rihab SVT*" [*In the Realm of Life and Earth Sciences*] and "*Al Jadid Fi SVT*" [*The New in Life and Earth Sciences*] specifically designed for first-year of the baccalaureate program (11th grade). The present study focuses on addressing various aspects associated with the concept of homeostasis, with a particular emphasis on blood glucose regulation. To carry out this study, we adopt a contrastive approach based on the typology proposed by Bernard *et al.*, (2007). This approach allows us to compare and contrast all the different sections in which concepts related to homeostasis are presented in order to identify errors, divergences and inconsistencies in both textbooks. We also draw on Chiappetta *et al.*, (1991, 2004) recommendation for analyzing science textbooks. They emphasize that the first step to have a proper textbook analysis is to raise the following question: Which unit or aspect of the selected textbooks should be analyzed? The list includes, but not limited to, definitions, paragraphs, pictures, illustrations and figures. For the purpose of the present study, we aim to have a contrastive approach of both texts that take all these elements into consideration. At this stage it is worth mentioning that the Moroccan ministry of education approves a wide range of textbooks associated with Life and Earth Sciences subject; yet, the choice of these two particular ones is not arbitrary; however, this choice is made based on the data collected using an online survey asking Moroccan teachers about their preferences. These two books, in particular, emerge to be the most used by the teachers in Morocco (Aidoun, 2019). These textbooks have been available in the market from 2006 to 2023.

The lesson on blood glucose regulation spans over 18 pages in "*Al Jadid*" textbook and 17 pages in "*Fi Rihab*" textbook; a total of 35 pages are analyzed in our study. The analyzed textbooks are heterogeneous, consisting of texts, tables, curves, and diagrams. As part of our study, we also aim to identify the potential impact of didactic transposition on the presentation of blood glucose regulation. Our study consistently draws on solid scientific references that contribute to the enrichment of knowledge produced in the field of teaching blood glucose regulation. The comparative and contrastive approach will allow us to critically evaluate the nuances in these Moroccan high school textbooks and make recommendations to improve the teaching of this key concept.

Results and Discussion

1. *The problem-based learning situation in both textbooks*

Problem-based learning plays a crucial role in the students' learning process. It can promote the development of critical thinking skills, problem-solving abilities, and communication skills. It can also offer opportunities for group work, finding and evaluating research materials, and lifelong learning (Duch, 2001). While analyzing the textbooks, we observe a significant difference between them as far as the scenarios offered to students in concerned. Unlike, "*Fi Rihab*" textbook, which presents the problem situation that triggers students to raise questions, "*Al Jadid*" textbook does not provide any problem situation. The absence of

the problem situation to introduce the notion of blood glucose regulation in "*Al Jadid*" textbook raise significant issues that needs to be taken into consideration. Such absence may lead to a lack of engagement and interest from the students' part, as they are not confronted with intellectual challenges that encourage them to think critically about the targeted notion deeper.

2. Techniques of Blood Glucose Measurement

As far as blood glucose measurement techniques are concerned, "*Fi Rihab*" textbook refers to two popular techniques: (1) using test strips and (2) using electronic device. This comprehensive presentation of blood glucose measurement techniques does not only broaden students' understanding of each technique, but also underscores the limitation of relying on a single one. In contrast, "*Al Jadid*" focuses exclusively on the use of the electronic devices for blood glucose measurement while neglecting the use of strips. Whereas this approach offers a straightforward introduction to one technique, it leaves learners with a restricted perspective. Understanding that different scenarios may call for distinct techniques and that each has its unique advantages and limitations is essential for a well-rounded comprehension of blood glucose measurement.

3. The Role of the Liver in Blood Glucose Regulation

a. Claude Bernard's "washed liver" experiment:

Surprisingly enough, "*Al Jadid*" textbook does not mention Claude Bernard's "washed liver" experiment, which holds significant historical importance in the field of physiology. This experiment represents a crucial step in research aimed at understanding glucose metabolism and the liver's role in this function (Louis Schlienger *et al.*, 2020). It is regrettable that this particular textbook does not cover this experiment. The omission of this experiment in the textbook can be seen as an obstacle that hinders a comprehensive understanding of the history of scientific research and the evolution of knowledge within this field. Lexis & Julien (2022) aptly pointed out that science education, particularly in high school and university, often relies on textbooks that present scientific knowledge as static, absolute facts, without conveying that these 'facts' are the current best understanding resulting from years of scientific experimentation, to truly grasp science, students need to comprehend how scientists conduct research and acquire knowledge.

In contrast, "*Fi Rihab*" textbook does invoke this experiment, but it's essential to underscore the absence of any reference to Claude Bernard himself, which results in the experiment being detached from its historical context. To provide a more holistic education, we should focus on raising students' awareness regarding the significance of researchers and scientists who have made substantial contributions to the advancement of scientific knowledge. This involves exposing students to different theories, experiments, and key figures in the field, enriching their understanding and enabling them to approach scientific concepts within their historical contexts.

b. Comparing Blood Glucose Levels in intra- and extra-hepatic blood:

While analyzing and comparing intra hepatic blood glucose values, we observed a significant divergence among both textbooks. In "*Al Jadid*" textbook, a blood glucose concentration of 0.8 g/L is mentioned, along with a fasting duration of only a few hours. However, this textbook does not specify the organism on which these measurements were performed. In contrast, the "*Fi Rihab*" textbook reports a significantly lower blood glucose value of 0.1 g/L and mentions that this value corresponds to measurements performed on a dog during fasting. However, it does not specify the duration of fasting in this context. Therefore, it is plausible that the differences in blood glucose values between these textbooks are a result of both variations in fasting durations and the use of a different organism for measurements. This highlights the importance of providing complete experimental context and details in scientific textbooks to ensure that students can interpret the data accurately and understand the factors that may influence experimental outcomes.

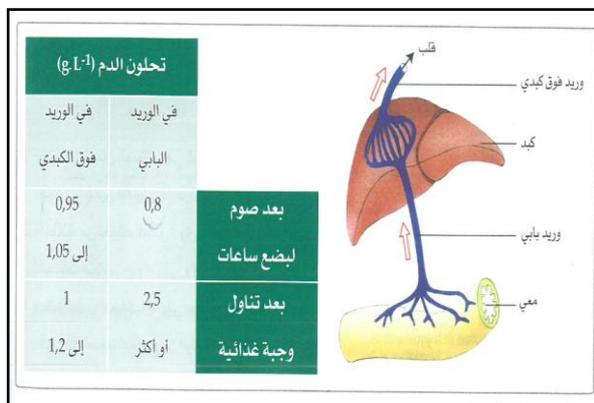


Figure 2: Blood Glucose Calibration intra-hepatic and extra-hepatic. "*Al Jadid*" p.70

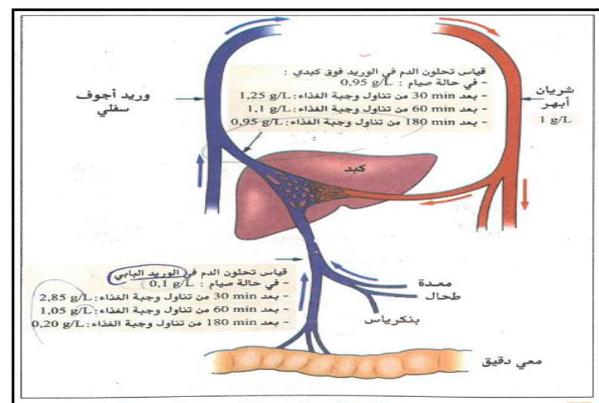


Figure 3 Changes in blood glucose intra-hepatic and extra-hepatic in dogs "*Fi Rihab*" p.78

In addition to the previous observations, it is relevant to emphasize that the "*Al Jadid*" highlights that the blood flowing to the liver through the hepatic portal vein comes exclusively from the small intestine. On the other hand, "*Fi Rihab*" presents an illustration indicating that the blood supplying the liver comes from both the small intestine and other organs such as the stomach and spleen. This lack of clear information in "*Al Jadid*" may hamper the clarity and relevance of the knowledge conveyed to the students. Hence, it is essential for textbooks to be based on reliable scientific sources and to provide accurate and coherent information to avoid any potential overlapping. (Chyleńska & Rybska, 2019)

4. Glucose Storage in the Body:

a. Forms of Glucose Storage in The Body

There are three microscopic observations "Al Jadid", namely liver cell, muscle cell, and adipose cell. However, it is worth to mention that the information associated with the observation of muscle and adipose cells do not specify whether an optical or an electron microscope was used, which limits our assessment of the provided information. It is, therefore, crucial to clarify the observation and staining methods used, as well as to specify the magnification level employed, in order to give students a precise idea of the actual dimensions of the cells.

Furthermore, it should be emphasized that there is no legend for the microscopic observation of the adipose cell to illustrate its relationship with glucose storage. This raises a gap in the information conveyed to the students.

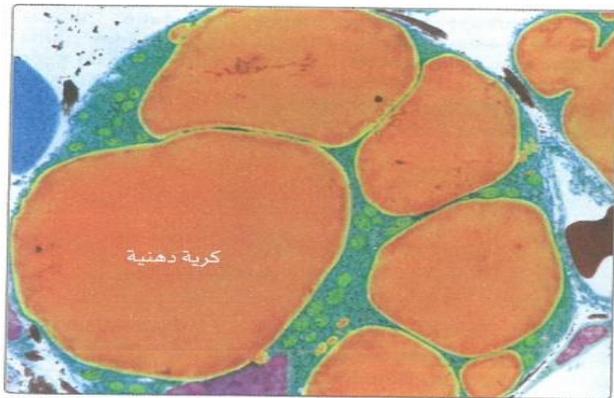


Figure3 : Microscopic observation of a fat cell "Al Jadid" p.72



Figure4: Microscopic observation of a muscle cell "Al Jadid" p.72

In "Fi Rihab" we identified a similar remark. The microscopic observations of muscle cells, as well as of adipose tissue do not provide any information about the type of microscope used, the staining method, or the magnification level. This lack of details makes the illustrations unusable from a pedagogical standpoint (El hamoumi, 2022) and can negatively impact our ability to adequately evaluate and interpret the given observations. It is, therefore, crucial to specify these technical details to ensure a precise understanding of the observations and to ensure the reliability of the information conveyed to the students. Yet, it is noteworthy that the microscopic observation of the liver cell provides all the necessary information on the observation process, which is valuable.

b. Glycogenolysis and Glycogenesis:

Both textbooks "*Fi Rihab*" and "*Al Jadid*" only cover the two reactions related to glucose storage and release, namely glycogenolysis and glycogenesis. However, they neglect to include information about gluconeogenesis, which is a reaction of great importance in maintaining blood glucose levels, and which is performed by the liver during prolonged fasting. Gluconeogenesis allows the liver to produce glucose from non-carbohydrate substrates including lactate, pyruvate, propionate, glycerol, and amino acids (Wang et al., 2023). By incorporating information about this metabolic reaction, the textbooks would surely enable students to have a more comprehensive and accurate understanding of glucose metabolism and its crucial role in the body's energy homeostasis.

In addition to this, "*Fi Rihab*" focuses only on the liver as the only organ capable of performing both reactions in study (glycogenolysis and glycogenesis). However, in "*Al Jadid*", it is noted that the muscle can also perform both reactions. Additionally, it specifies that the muscle cannot release sugar into the bloodstream but rather uses it for its own activities in case of a decrease in the sugar level in the body. This highlights the important fact that not only the liver but also muscle tissue plays a significant role in glycogen metabolism, contributing to a more comprehensive understanding of glucose regulation in the body. (Gupta, 2022)

5. The Role of the Pancreas in Blood Glucose Regulation

a. The lesson's Objectives

Upon examining the objectives related to the specific section titled "The Role of the Pancreas in Blood Glucose Regulation" within the lesson, we have observed that the editors of "*Al Jadid*" have overlooked a crucial objective among those stated. This omitted objective is centered on the development of the concept of hormones and endocrine glands, which is particularly vital as hormones are the primary focus of this lesson related to "blood glucose regulation". It is noteworthy that the textbook includes some documents and definitions of hormones and endocrine glands in the few pages dedicated to this section. This lack of alignment between objectives and content can potentially create confusion among both students and teachers. It is imperative for the objectives to be in harmony with the actual lesson content and the concepts that require coverage. Otherwise, students may find themselves adrift, impeding their ability to meet the intended lesson objectives. In plainer words, rectifying these inconsistencies is of paramount importance. Ensuring that the objectives accurately mirror the content of the lesson is essential. This alignment enables students to better grasp the course activities and, subsequently, improve their performance in assessments (Orr et al., 2022).

b. The Pancreas and regulation

In "*Fi Rahab*", there is a document that clearly illustrates the position of the pancreas in the human body and its vascularization. Such illustration is crucial as this part of the lesson deals with the role of the pancreas in regulating blood glucose. Unfortunately, "*Al Jadid*" provides no illustration that shows the position of this organ in the human body. It goes without saying

that the absence of such detail in the textbooks -as a major learning material- could have a negative impact on students' overall understanding. Neglecting such details about the position of the pancreas in the human body and its vascularization could impact students' understanding of the functions of the pancreas in blood sugar regulation and the significance of its vascularization in providing oxygen and nutrients.

c. Hormones involved in Blood Glucose Regulation

In both textbooks, they only focus on insulin and glucagon as the only hormones responsible for regulating blood glucose levels. In fact, there are other hormones that have an impact on this regulation, namely adrenaline, cortisol and growth hormone. In so doing, the editors of these textbooks might be tempted to simplify knowledge and concepts. Yet, such oversimplification might have an adverse result on students' overall grasp of the concept of blood glucose regulation. In the same vein, Yucel (2023) states that the over-simplification of knowledge can lead to a generalised distrust of science.. In other words, reducing and oversimplifying this notion might be at the expense of a comprehensive understanding of the complex interaction between different hormones and their contribution to maintaining blood glucose balance in the body. By narrowing down the discussion to only these two hormones, a whole learning process of blood glucose regulation can be hindered. It is, therefore, important to emphasize the need to provide an overview of all the hormones associated in this regulating system, and how they interact to maintain proper blood glucose levels. Plainly put, students need to be thoroughly informed about the different hormones involved in this process. This will enable them to understand that insulin and glucagon are just two examples among other. Having such extended knowledge will allow students to gain a deeper understanding of this vital process.

6. Structures responsible for the secretion of insulin and glucagon

a. The identification of insulin-secreting and glucagon-secreting cells

When it comes to the experimental data highlighting the role of different pancreatic cells in both textbooks, it is reported that the injection of alloxan in rabbits leads to the development of diabetes in these animals, but, without, specifying its chemical nature and the reason for its use. It is important to make it clear that alloxan is a chemical compound used in laboratories to induce the onset of diabetes mellitus in laboratory animals, especially rabbits. The injection of alloxan in these animals causes lesions in the β -cells of the pancreas, which are responsible for insulin production. This alteration leads to a decrease in insulin secretion, resulting in elevated blood glucose levels and the development of symptoms similar to those of diabetes.

Generally Speaking, biology textbooks should provide more detailed information about alloxan, its specific mode of action on β -cells of the pancreas, and the reasons for its use in experimental studies on diabetes. This -by extension- should include all the chemical substances used in scientific experimental. Such details would enable students to have a deeper understanding of the biological mechanisms and research protocols used in this field. In a similar vein, a close reading of the section about "pancreatic structures responsible for the secretion of insulin and glucagon" in "*Fi Rihab*" reveals the presence of an error. It is mentioned that "[...] *ligature of the pancreatic duct leads to digestive disorders in the*

regulation of blood glucose". In fact, ligation of the pancreatic duct does indeed lead to digestive disorders, but it does not affect the regulation of blood glucose. Instead, they should have stated that during this ligation, the pancreatic acini undergo degeneration. Such instances underscore the worldwide need for rigorous updating of science textbooks, as demonstrated by the outcomes of an international meeting held in 2007, which emphasized the global importance of such revisions (Bizzo & Caravita, 2012)

b. The target cells of glucagon

Unlike "*Fi Rihab*" which does not limit the target cell of glucagon to the liver alone, "*Al Jadid*" textbook presents the target cells of glucagon as being exclusively located in the liver. Unfortunately, this is not true. As a matter of fact, glucagon exerts effects on multiple tissues in the body. While its primary action is manifested in the liver, where it stimulates the release of glucose, it also affects other tissues. It promotes lipolysis in adipose tissue, leading to the breakdown of triglycerides into free fatty acids that can be used as a source of energy. In addition, glucagon also acts on muscle cells. By not providing an incomplete definition and illustration of the target cells of glucagon, learners may have a limited understanding of the hormone's action in the body. This can impact their overall understanding of the role of glucagon in blood glucose regulation.

Conclusion:

The present study used the content analysis method to systematically analyze the section of blood glucose homeostasis in two Moroccan *Life and Earth Sciences* textbooks used by 11th grade students (=first year of baccalaureate), enrolled in experimental science track. This study is part of a larger project which aims to explore the difficulties encountered by Moroccan students while learning homeostasis as a fundamental concept in biology in secondary school and college. It is also part of a very wide and ever-evolving area of research, which is textbook research. In this regard, this study derives its legitimacy and significance from:

1. The urgency of studying blood glucose homeostasis in the Moroccan context, especially with the constant increase of obesity and diabetic cases within Moroccan families and students as well.
2. The lack similar research projects not only in Morocco, but also in the African continent as I mentioned earlier.

The results have highlighted several shortcomings, errors, and inconsistencies that have been discussed in detail above. Unfortunately, such shortcomings can hinder the overall understanding of major biological and physiological processes related to glucose regulation in the body. This study started with the prism that textbooks play a vital role in the learning-teaching experience. Therefore, it calls for the importance of checking the accuracy of information provided in textbooks in order to successfully ensure a quality scientific education. In other words, the recurrence of such mistakes in these books surely leads to some confusion and misconceptions. It is, therefore, recommended to take action to correct an address all the errors and inconsistencies identified in the textbooks. This may involve a

thorough revision of content, collaboration with experts in the field of biology and education. Also these textbooks should be subjected to regular updates in their future editions.

The results of this study are limited in several aspects, and further research should be conducted in this area, taking into consideration other textbooks and other disciplines. Finally, this study serves as an open invitation to promote a critical and analytical mindset among students and teachers when using textbooks. They should be encouraged to ask questions, validate facts, and consult reliable sources to deepen their comprehension of the subjects being studied.

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