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The Use of Digital Resources in Conceptual Change, an Essential Factor in Improving Learning

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Abstract

Teaching and learning occupy a major place all over the world, as the sustainable development of all sectors is linked to the improvement of the educational system.

The COVID 19 experiment showed that the place of ICT in the learning process is not optional but essential, and that mastery of the computer tool is an asset that will serve the pedagogy and ensure the continuity of learning whatever the circumstances.

The objective of our work is to evaluate the impact of the introduction of the computer tool on the quality of learning and the realization of conceptual change in learners. That is why a learning situation was carefully prepared, aiming at students of the first year of the baccalaureate in experimental sciences, from a public high school "Khadija Oum Almouminin"; dealing with the chapter of the regulation of glycemia of the Moroccan program in Life and Earth Sciences (LES). The learning situation was carried out with a pilot group to which we introduced the computer tool and another control group with which we worked on the same chapter but without using ICT. The analysis and comparison of the results allowed us to verify the problematic posed and to propose perspectives to ensure conceptual change in the learners.

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I. Introduction

Conceptual change is a challenge to the success of the learning process. For we cannot speak of effective teaching if it does not meet the requirements; in other words, if it does not allow learners to move from intuitive, often erroneous, conceptions to structured scientific conceptions.

With the digital revolution, the computer tool has begun to take its place in several areas, including teaching-learning. However, several international research and field studies have shown the positive impact of the introduction of ICT in education (Benfares et al., 2015; Guennoun et al., 2016). Through the improvement of pedagogy, offering the learner a better relationship to knowledge (Karsenti, 2001), reinforcing his or her motivation and profoundly modifying his or her strategies for learning as well as those of the teachers to make learn (Klein, 2013); especially when ICT is introduced in a diversified didactic approach carefully structuring the learning activities (Barrette, 2004).

Morocco, like most countries in the world, has become aware of the importance of the use of ICT in the educational system; and has implemented, as early as 2005, the Genie program which aimed at the generalization of ICT in schools; in addition to other projects and programs that aimed at the same objective; namely, the Genie Sup program and the Nafida project in 2008, the injaz operation in 2009, the national portal Taalimetice in 2011... (Nafidi et al., 2018).

However, despite the efforts put in place and the effective commitment of the Moroccan government, the use of ICT remained limited until the pandemic crisis, which showed that pedagogical continuity can only be ensured through their use.

The experience of the containment period, following the spread of the COVID 19 pandemic, has shown that the time has come to renew teaching methods, in order to make them adapted to new needs and requirements. To optimize the chances of ensuring learning that leads to conceptual change in learners (FATHI & al. 2022).

II- Context

The present work is part of the didactic research in the scientific subjects interested in the conceptual changes in the learners. We have carried out a learning situation, aiming at identifying the impact of the introduction of ICT in the teaching process, on the quality of learning as well as on the realization of conceptual change in the students in the subject of life and earth sciences.

The COVID 19 experience has shown the indispensability of ICT in the teaching process to ensure pedagogical continuity and completion of the curriculum (S. FATHI & al. 2022). This experience has left a wealth of digital resources that can be used or developed to support learning, even in the post-pandemic period.

III- Problematic

Life and earth sciences is an experimental discipline that aims at developing several skills in the learner, namely critical observation, analysis, interpretation of results.... However, sometimes teachers are not able to carry out experiments in class, due to various constraints such as lack of equipment in the laboratory, overcrowded classrooms, busy curriculum… And this is where the role of ICT comes in, as it allows the student to get closer to the scientific concept and to see in a reduced or accelerated model events that are not accessible to direct observation due to time or space (El Ouidadi et al., 2013). To what extent will the introduction of ICT in the learning process influence its quality and the achievement of conceptual change in LES learners?

IV- Working methodology

Our study is based on a carefully prepared learning situation, drawing on the remarks of teachers who have already worked on the conceptual change, in addition to the long experience of practitioners. The learning situation was implemented over a period of six weeks, after the authorization of the responsible organizations; in addition to a statistical study of the students' results in the three continuous tests in Life and Earth Sciences established in the first semester of the same school year. The research team is composed of two professors of higher education, a provincial director, an inspector of life and earth sciences and a teacher of life and earth sciences at the high school level.

1- Objective

The objective of our work was to verify the impact of the introduction of ICT in the teaching process on students' learning and understanding, their motivation and the achievement of a conceptual change in LES.

2- Sample

In a population of 228 students of first year baccalaureate experimental sciences, distributed on six classes and belonging to the same public high school "Khadija Oum Almouminin". We chose to work with a sample of sixty-nine students belonging to two different classes of close levels, according to the results obtained in the first semester, by comparing the averages of the two classes in the three controls carried out in LES. A pilot class of thirty-eight students and a control class of thirty-one students; that is, 30.26% of the population.

3- Didactic tools

Our learning situation was carried out in five steps:

Diagnostic evaluation: In order to extract the intuitive conceptions of the students in relation to the concept of blood sugar regulation and to familiarize them with the use of the computer tool for educational purposes; a diagnostic evaluation of eight questions was proposed remotely to the students of the two classes via the Google forms platform.

Course: Thirteen hours of course spread over three and a half weeks; that is to say two sessions of two hours per week;

were proposed to the students of the two classes in relation to the chapter of the regulation of the glycemia, following the official pedagogical instructions and the curriculum of the first year of the baccalaureate experimental sciences in the matter of Life and Earth Sciences. This chapter is part of the unit of nervous communication and hormonal communication. The choice of this chapter was not random, but rather well thought out, given that diabetes represents a very common disease, and every student knows someone with diabetes from near or far. Moreover, this chapter represents the continuity of the unit "Functions of Relation" that the students have already studied in the LES program of the 3rd year of secondary school.

Formative evaluation: To assess the extent to which students have assimilated the course and the extent to which the learning has resulted in the realization of a conceptual change in them. A formative evaluation in class was proposed to the students of both groups.

Remediation and regulation: A one-hour remediation session was planned for both classes separately. For the pilot class, we presented two well-selected videos from Youtube, which model in a simplified way the process of blood sugar regulation. The session was closed by a discussion among the students about the studied phenomenon. For the control class, we summarized the course in the form of a detailed scheme on the board, and then we gave the students time to ask questions and to exchange ideas about the topic studied.

Summative evaluation: The same evaluation was submitted to the students of both classes, to compare the results and to see the impact of the introduction of ICT, through the modeling of the studied phenomenon by educational videos, on the students' understanding and the realization of a conceptual change in them.

V- Analysis and discussion

According to the results obtained in the diagnostic assessment, 89% of the learners were able to define blood glucose, since this concept is very popular, given the abundance of diabetes cases in the world. On the other hand, 11% were either unable to define it or gave incorrect definitions (Table 1, Q1).

Table 1. Student responses to diagnostic assessment questions 1 and 2

Questions	Percentage of student responses	
	Right	False
Question 1: Define blood glucose	89%	11%
Question 2: What is the blood glucose level in a normal person?	38.6%	61.4%

The majority of the students in the sample studied, with 61.4%, did not know the normal level of blood glucose, while only 38.6% were able to give the correct answer (Table 1, Q2).

When we talk about blood sugar levels, we automatically talk about the organs responsible for regulating the level of glucose in the blood. According to the results, most of the students knew only the pancreas as an organ involved in the regulation of blood glucose, with 77.3%; and only 25% cited the liver. On the other hand, the rest of the students mentioned organs that are not involved in the process studied, such as: kidneys (11.4%), lungs (4.5%), gallbladder (2.3%). This highlights the misconceptions among the students (Figure 1).

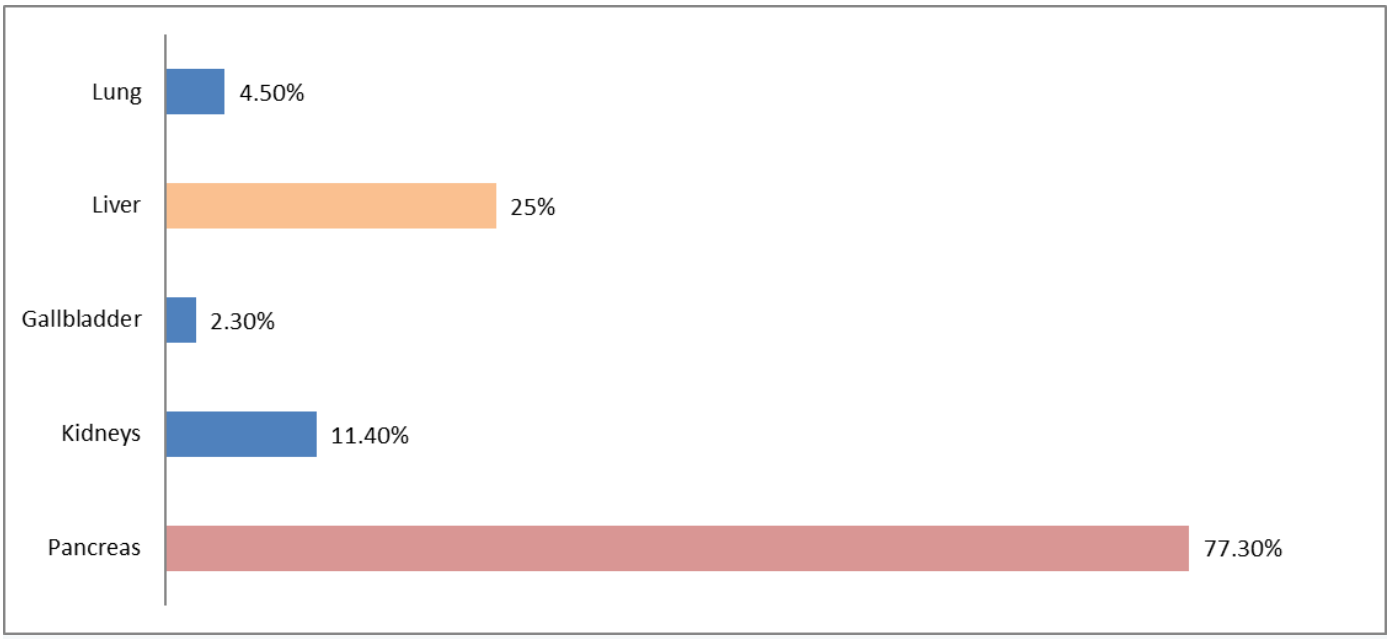

Figure 1. *Student response to question 3 of the diagnostic evaluation in relation to the organs involved in blood glucose regulation.*

Almost 40% of the students were aware that the communication between the organs responsible for the regulation of blood glucose is done by humoral way. Especially, they noticed that diabetics give themselves injections to regulate the level of glucose in their blood. While the rest, with 60%, were either unable to answer, or gave a wrong answer to the question. Among the intuitive misconceptions that we were able to find, we mention: it is a nervous communication, the brain gives the order to the target organs; while others were unable to distinguish between a communication pathway and the substance responsible on the regulation, since many answered with insulin (Figure 2).

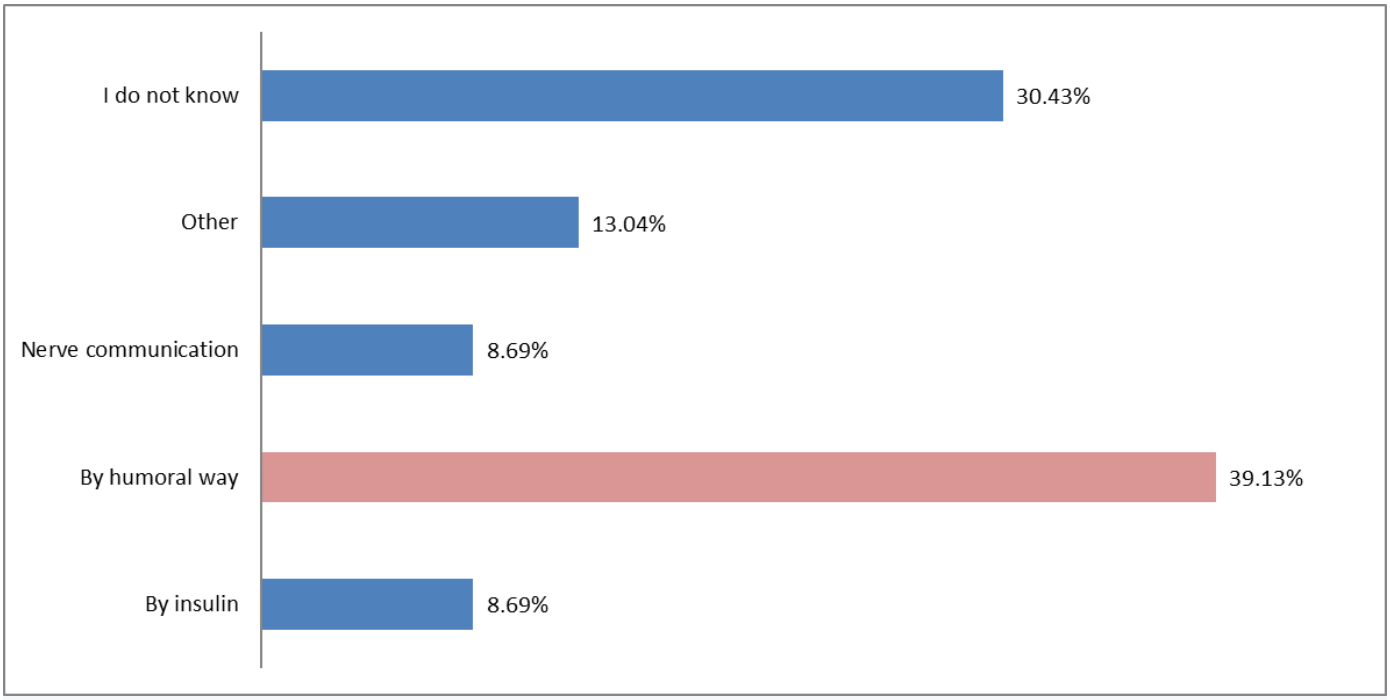

Figure 2. *Student response to question 4 of the diagnostic evaluation in relation to the communication pathway between organs during blood glucose regulation.*

Given the high frequency of diabetics all over the world, almost all of the sample studied, with 98%, knew that the substance injected by diabetics is insulin (Figure 3). However, only 56.8% of them knew that the nature of this treatment is a hormone. Whereas, 22.7% thought that insulin was a sedative, and 20.5% thought that it was a nerve impulse. This again highlights the intuitive misconceptions of 43.2% of the study population (Figure 4).

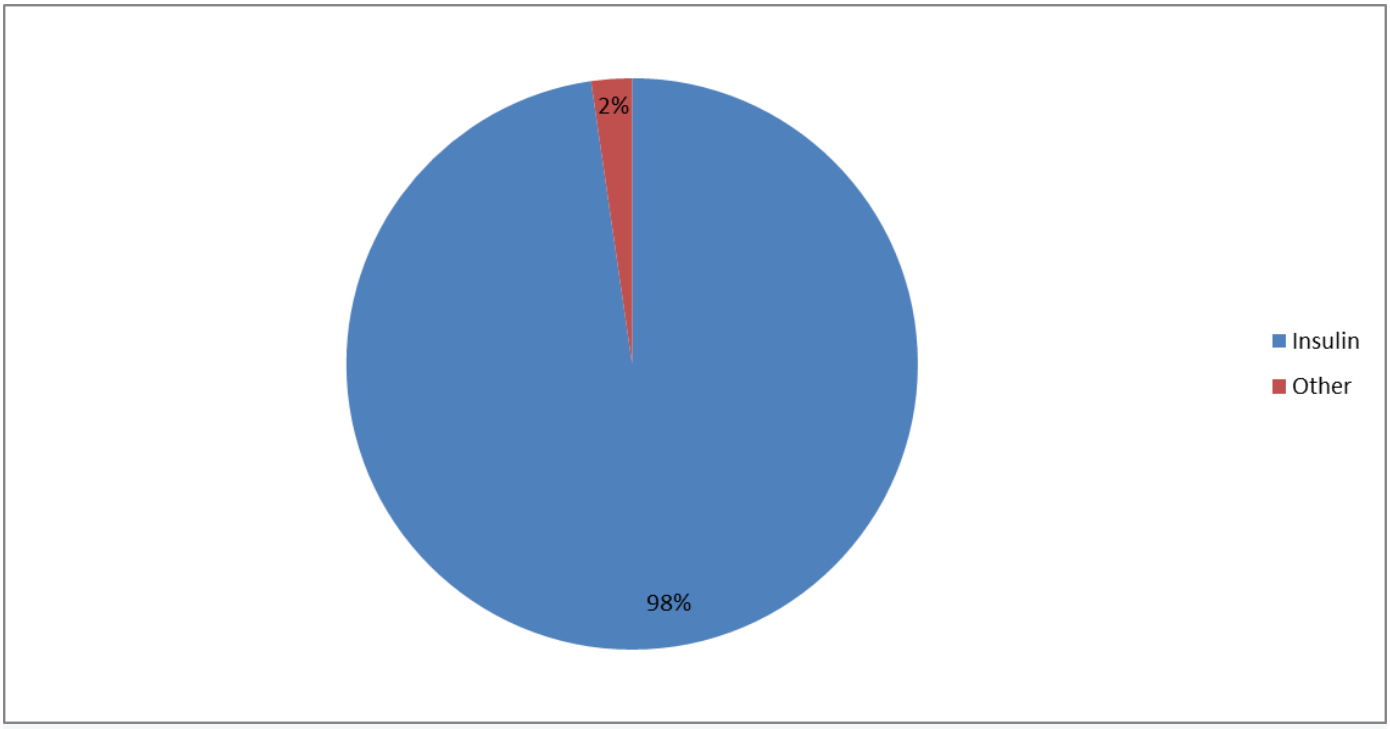

Figure 3. *Student response to question 5 of the diagnostic evaluation in relation to the substance injected by diabetics.*

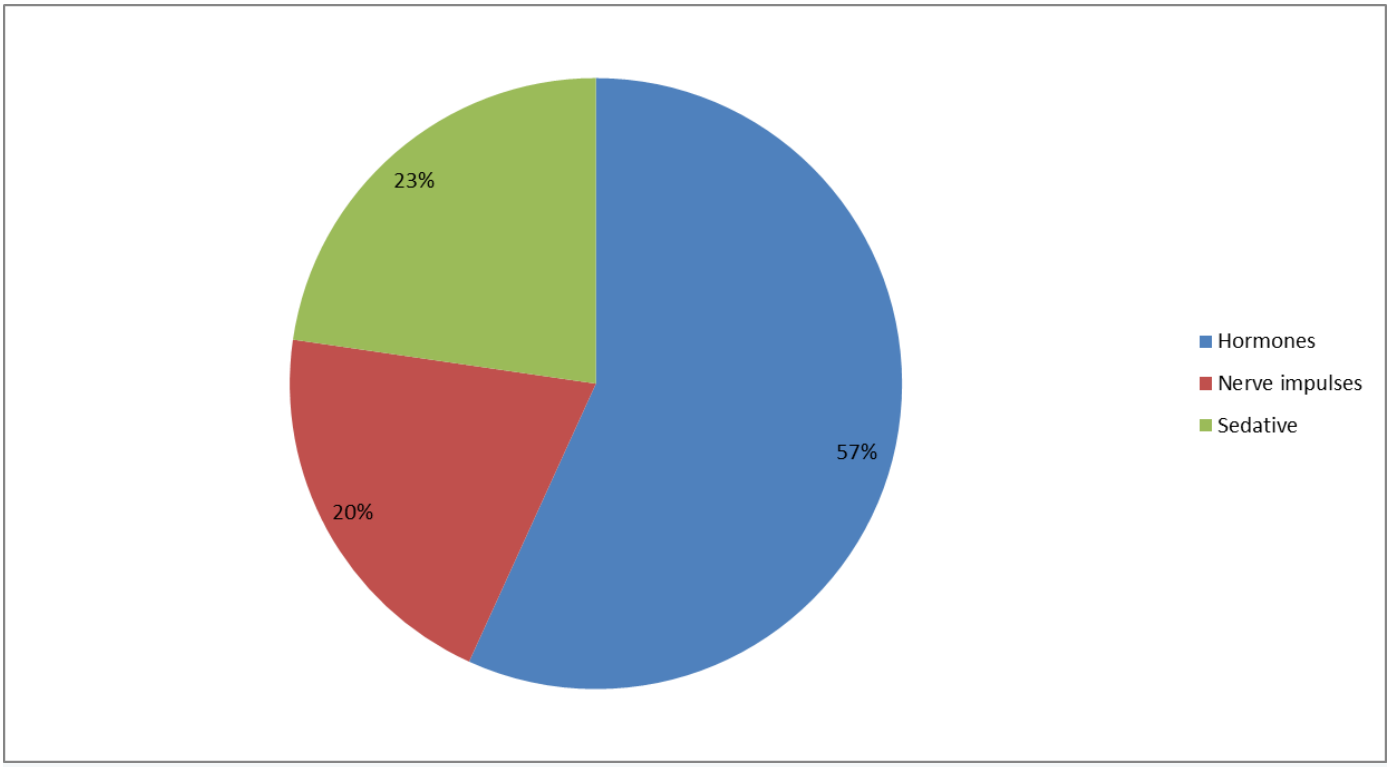

Figure 4. *Student response to question 6 of the diagnostic evaluation in relation to the nature of the substance injected by diabetics.*

The results also show that 68.2% of the learners know that the body stores excess glucose from the diet. On the other hand, 22.7% thought that the body rejects the excess in the form of waste; and 9.1% thought that all of it is consumed during digestion (Figure 5).

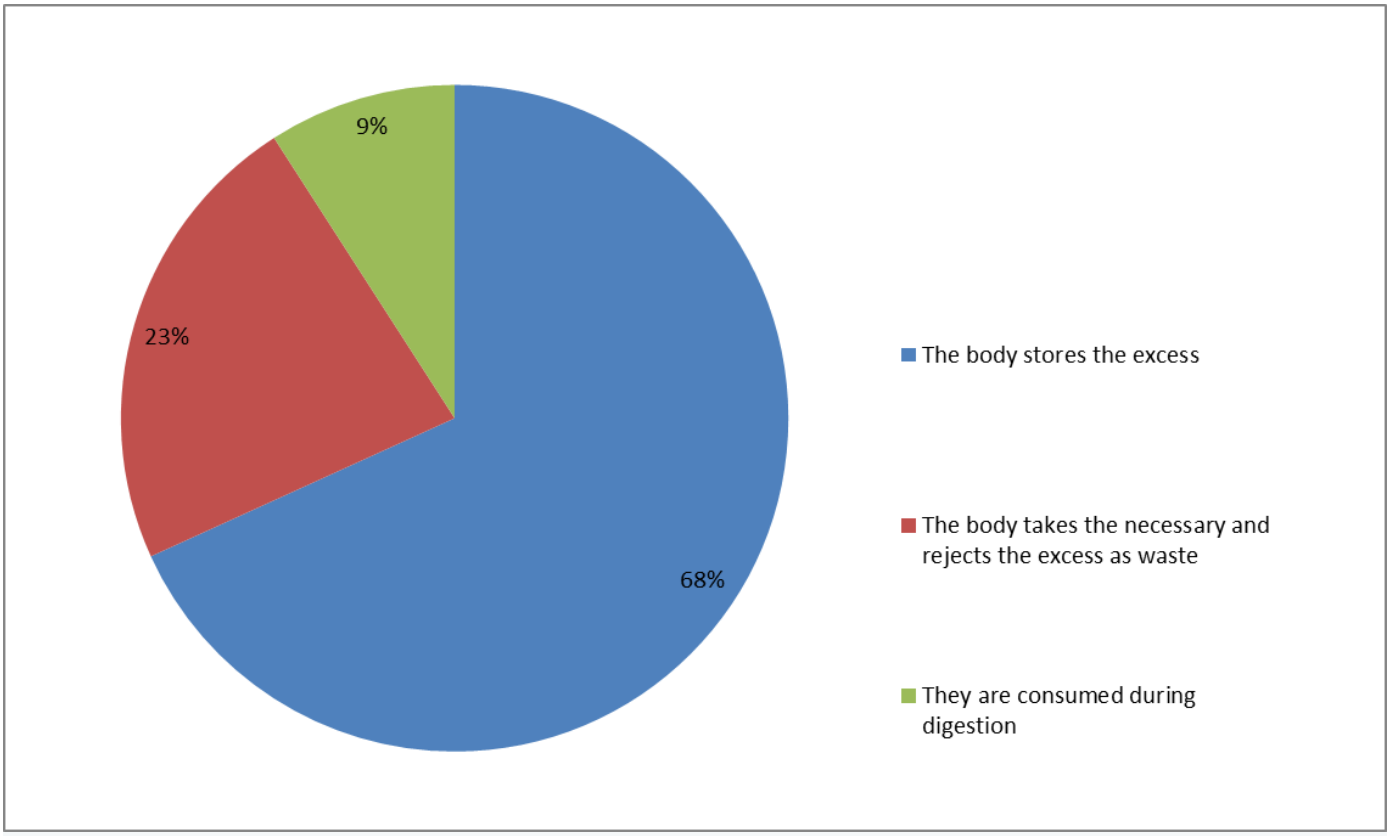

Figure 5. *Students' response to question 8 of the diagnostic evaluation in relation to what has become of the excess glucose in the body from food*

From the diagnostic evaluation, we were able to extract many of the learners' intuitive misconceptions about the process of blood glucose regulation. Hence, the objective of the next step is to ensure learning that leads to conceptual change in them.

Following the official instructions and the curriculum of the Ministry in relation to the teaching of this chapter in the matter of Life and Earth Sciences; we ensured to the students of the two classes, control and pilot, a well-structured course of 13 hours, spread out over three and a half weeks, using the textbook and the handout of figures as didactic supports accompanying the learning.

Afterwards, in order to verify the extent to which our teaching had led to a conceptual change in the learners, a formative evaluation of two exercises was submitted to the students of both classes. The first one concerns the restitution of knowledge. It consists of two questions; in the first one we asked the students to define the concepts of hormone and blood glucose. We found that the majority of students, both in the pilot (80%) and control (56%) groups, were able to define hormone, whereas during the diagnostic assessment, the majority of participants were unable to answer or gave an incorrect definition. This shows the conceptual change in the majority of the students in relation to this concept. However, we also notice that some learners still appeal to their initial conceptions or are unable to answer, which leads us to conclude that the teaching did not result in the realization of a conceptual change in this category, with regard to the concept in question (Table 2).

Table 2. *Student response to the first question in Exercise 1 of the formative assessment in relation to the definition of hormone and blood glucose.*

Definitions	Student Answers			
	Control Group		Pilot Group	
	True	False	True	False
The hormone	56%	44%	80%	20%
The glycemia	83%	17%	68%	32%

Regarding the definition of blood glucose, 68% of the students in the pilot group and 83% in the control group were able to define the concept correctly. If we compare these results with the answers obtained in the diagnostic assessment (89%), we notice a decrease in the percentage of correct answers. This can be explained by the probability of fraud during the diagnostic evaluation, especially since it was carried out at home, via the Google forms platform. This shows that the computer tool detaches us from the limits of space and time, and allows for pedagogical continuity even outside the classroom. Except that it is difficult to control the behavior of students outside the classroom. However, we note that 32% of the students in the pilot group and 17% in the control group still use their initial intuitive conceptions. This shows that the learning did not lead to the realization of a conceptual change in this category (Table 2).

Table 3: Student response to the second question in Exercise 1 of the formative evaluation

Proposals	Student Answers					
	Control group			Pilot group		
	True with justification	True without justification	False	True with justification	True without justification	False
a- The blood glucose level is constant in a normal person at around 1 g of glucose per liter of plasma.	-	89%	11%	-	84%	16%
b- Hepatic cells store excess glucose in the vesicle as glucose phosphate.	32%	52%	16%	33%	50%	17%
c- The liver and muscle cells release glucose into the bloodstream when needed.	28%	28%	44%	16%	28%	56%

The second question was in the form of propositions to be answered by true or false with justification. The questions were designed to test the students' knowledge of blood gycemia levels; where the percentage of correct answers increased to 84% for the pilot group and 89% for the control group, compared to the diagnostic evaluation; where the percentage of correct answers did not exceed 39%. This shows that the majority of students in both groups are no longer using their intuitive misconceptions (Table 3, a).

The second proposal concerned the ability of liver cells to store excess glucose as glycogen. Where the answers of the students of both groups were almost identical. Namely, almost 84% gave the right answer, but only 32% of them were able to justify it. This proves that the sequence of steps in this process is not yet clear to the majority. Therefore, we cannot speak in this case of a real conceptual change in the learners. For the learning of a concept is not reduced to the memorization of its definition, but rather as the positioning of it in a network of knowledge that makes sense to the student (Reuter et al., 2013) (Table 3, b).

The question was also intended to test the students' knowledge of the role of muscle in blood sugar regulation. Where we found that only a minority were able to give the correct answer with justification; namely, 16% of the pilot group and 28% of the control group. On the other hand, 28% of the students in both groups gave the correct answer except they were unable to justify it. While the rest (56% of the pilot group and 44% of the control group) gave wrong answers (Table 3, c).

The second exercise was in the form of a problem situation, which highlighted the role of insulin and glucagon in the regulation of blood glucose. As well as the variation of their concentration in the blood, according to the glucose level. Only 20% of the students in the pilot group were able to give the right answer. While 50% of the students in the control group answered correctly. This shows that the teaching did not lead to a conceptual change in a large population of the study sample (Figure 6).

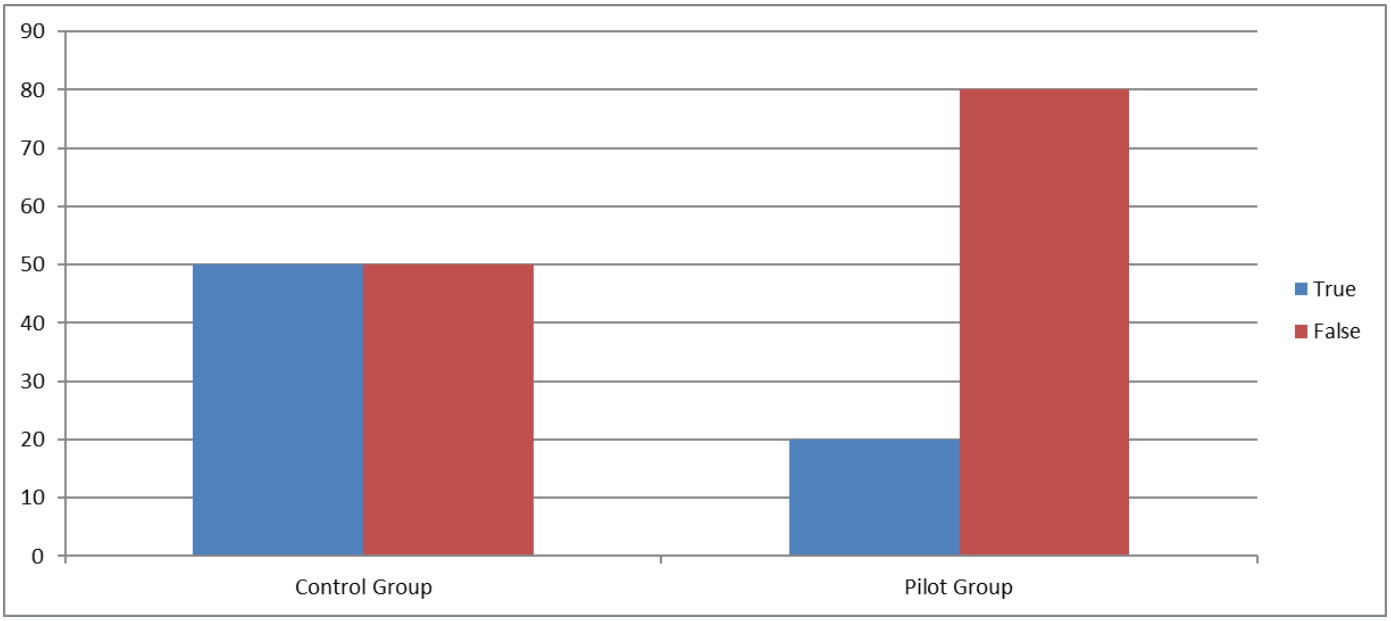

Figure 6. *Student response to the second formative evaluation exercise in relation to the roles of insulin and glucagon in the body.*

Comparing the results of the formative evaluation, it can be seen that the levels of the two classes are close; scoring more correct answers in the control group compared to the pilot group. Additionally, it is noted that students tend to retain and reference their initial conceptions even after lecture (Chiu et al., 2016). Especially when the context is changed or when the assessment of the timing of instruction is spaced (Potvin et al., 2015).

Right after, we organized a one-hour remediation session for each group separately. In this session, we proposed to the

students of the pilot group two videos chosen with precision from Youtube. The first one of 26 min 04s "Diabetes: sugar under surveillance - C'est pas sorcier" and the second one in the form of a 4 min video capsule "In the heart of the organs: glycemia", which models the process of glycemia regulation in a very simplified way, presenting the different organs involved as well as the hormones secreted in case of hyperglycemia or hypoglycemia and their course in the body as well as their influence on the target organs. The students really enjoyed this experience. They were more motivated, which was observed from the questions they asked and the debate that took place among the students in the remaining 30 minutes after watching the videos.

For the control group, we summarized the lesson during the remediation session, schematizing the process of blood glucose regulation on the board. Then we invited students to ask their questions, prompting them to enter into a debate about the process being studied.

Then we told the students in both groups when the summative assessment was due, which we scheduled in the next session. The evaluation consisted of two exercises. The first one was a knowledge restitution exercise with 3 questions. One was about the definition of scientific terms, the second was about propositions to which one had to answer by true or false, justifying the answer. The third was a summary question on the behavior of the body in case of hypoglycemia.

The second exercise was in the form of a problem situation that aimed to test the students' skills in graphing, analysis of results and deduction. In addition to the determination of the role of the liver in the storage of glucose in the form of glycogen, from the analysis of the data.

The same test was submitted to the students of both groups; the results of which are presented as follows:

Table 4. *Comparison of student outcomes for the two groups*

Parameters	Control group	Pilot group
Average of the three LES tests done in the 1st semester	12.11	12.58
Summative Evaluation Average	10.13	11.96
Standard deviation	4.96	3.86

Despite the fact that students in the control group gave more correct answers on the formative assessment. It is noticeable that the class average obtained during the summative evaluation was higher in the pilot group than in the control group. This shows the positive impact of the introduction of ICT on students' understanding and learning.

The majority of students in both groups with 93% were able to define the hormone. However, we note that there are still students who think that the pancreas is involved in digestion through hormones. Comparing the results of the two groups, we notice that 74% of the students in the pilot group were able to give the correct answer, including 28% who were able to justify it. This is in contrast to the control group, where only 33% of the students were able to give the right answer and only 13% were able to justify it. This shows that the video promoted understanding in more students in the pilot group

than in the control group (Figure 7).

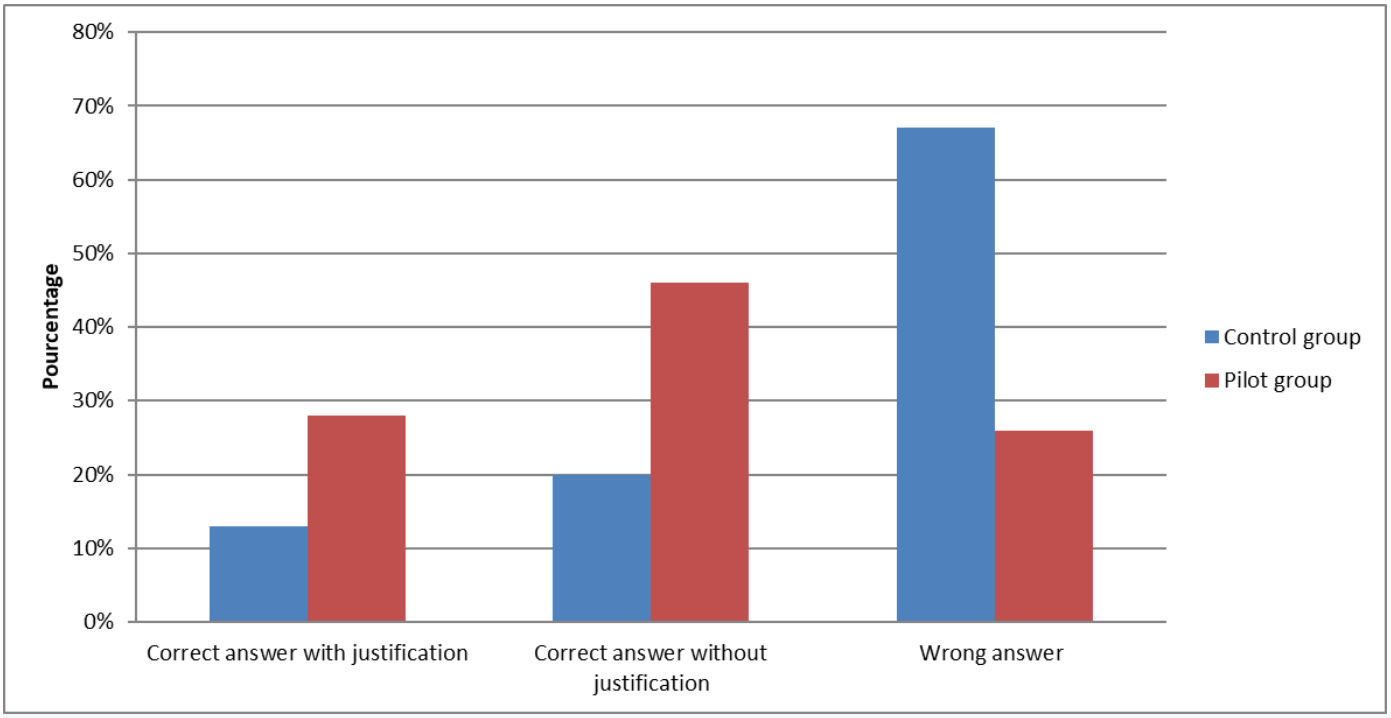

Figure 7. *Student response to the summative evaluation in relation to how the pancreas is involved in digestion.*

Almost all of the students in both groups know that cells secrete insulin when there is high blood glucose. And that fat cells store excess glucose as fat. Moreover, the cells self-regulate their secretions.

However, when students were asked to write a summary of the body's response to hypoglycemia. We noticed that 40% of the students in the pilot group were able to give a developed and detailed synthesis on the mechanism and 26% gave a synthesis that lacked detail while 34% gave a wrong answer. Comparing these results with those of the control group. We notice that only 30% of the students in this group gave a good and detailed synthesis, while 27% gave syntheses that lacked details and 43% gave wrong answers. This shows again, that when it comes to a question of synthesis or linkage between different steps of the blood glucose regulation process, the results of the pilot group are much better. Hence, the positive impact of watching the synthesis video on their memorization and on the realization of the conceptual change in a considerable percentage of the subjects studied (Figure 8).

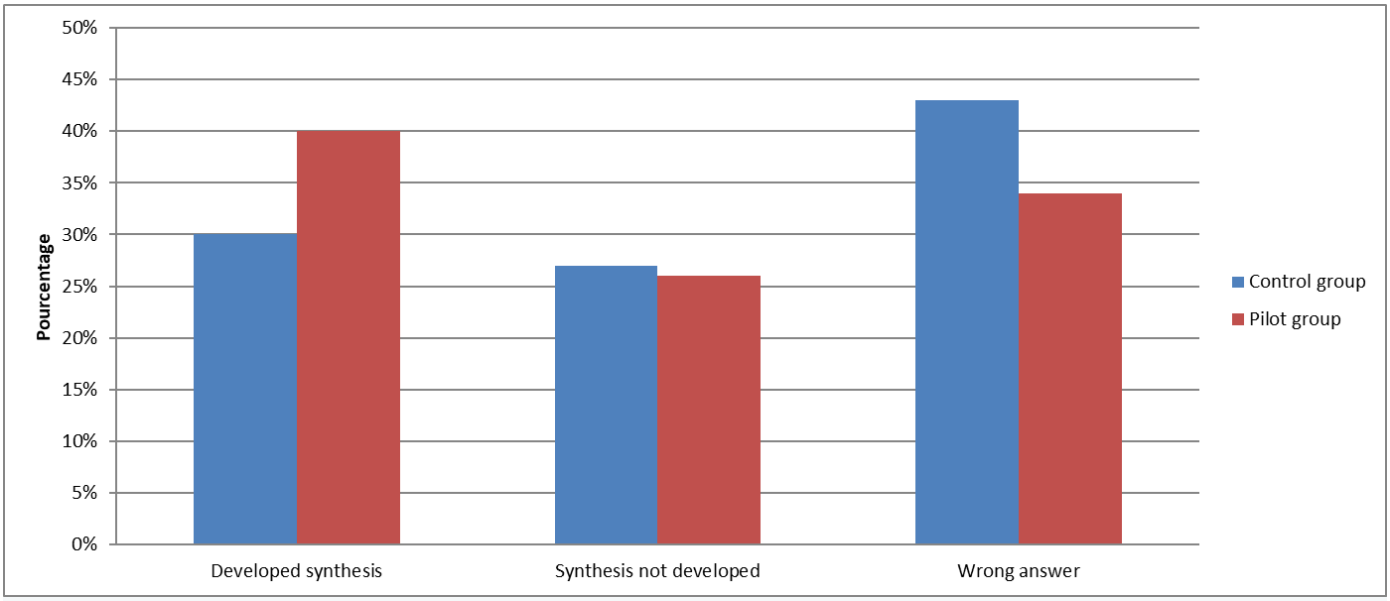

Figure 8. *Student response to summative evaluation in relation to body response to hypoglycemia.*

Graphing was not one of the issues addressed in the video. This explains why the results of the students in both groups were close to each other in relation to this question. On the other hand, we notice that the analysis of the curve was much better in the pilot group with 65.71% compared to the control group, where the percentage of students who gave a good analysis did not exceed 46.67%. However, for the deduction, only 33% of the students in both groups were able to give the right answer (Figure 9).

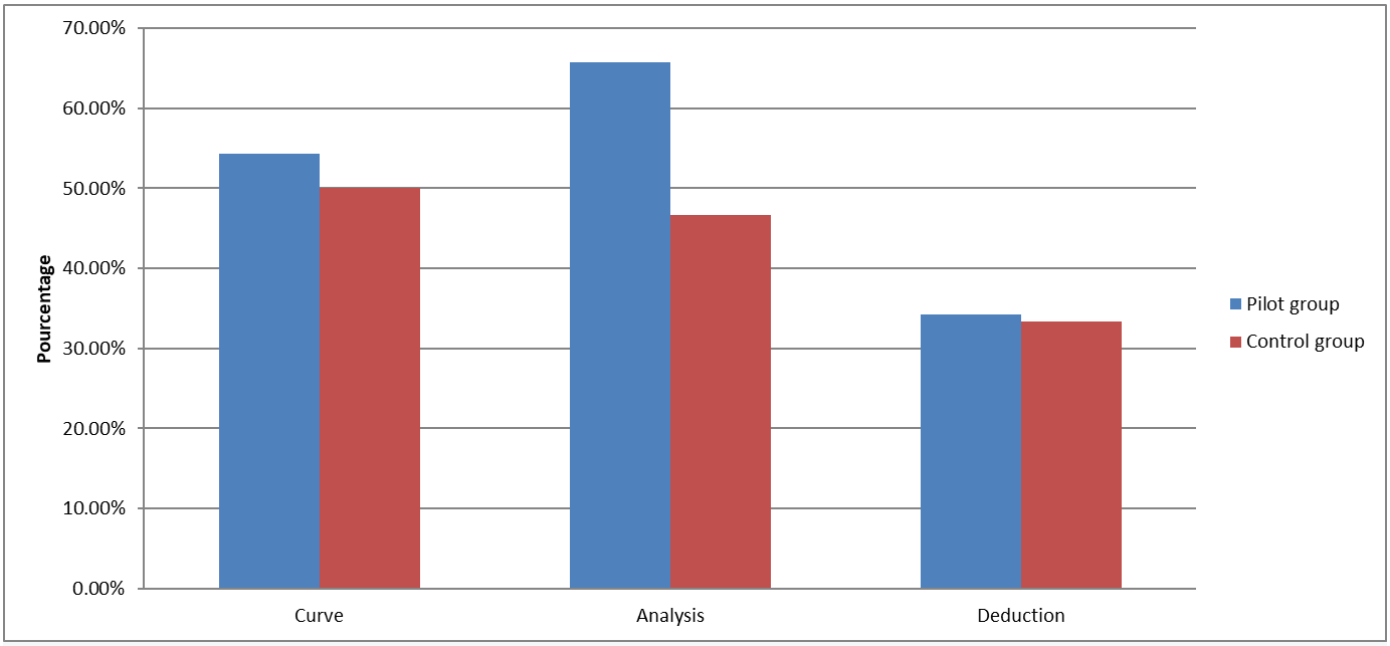

Figure 9. *Students' response to the summative evaluation in relation to the graphical representation of the variation of the level of insulin secreted as a function of the concentration of glucose in the medium its analysis and deduction*

In the last question, we presented to the students some data to exploit to come out with the role of the liver in the storage

of glucose in the form of glycogen. According to the results obtained, we notice that 31.43% of the students in the pilot group managed to give a complete answer while 14.29% gave an incomplete answer and 54.29% gave wrong answers. This shows that the majority of the students did not manage to use the documents correctly to answer the problem situation. Thus, putting the point of the realization of conceptual change in the learners in question. Comparing these results to the control group. We note that the results were lower in this group, since the percentage of students who gave a complete answer did not exceed 23.33% and those who gave incomplete answers 6.67%. While the percentage of wrong answers reached 70% (Figure 10).

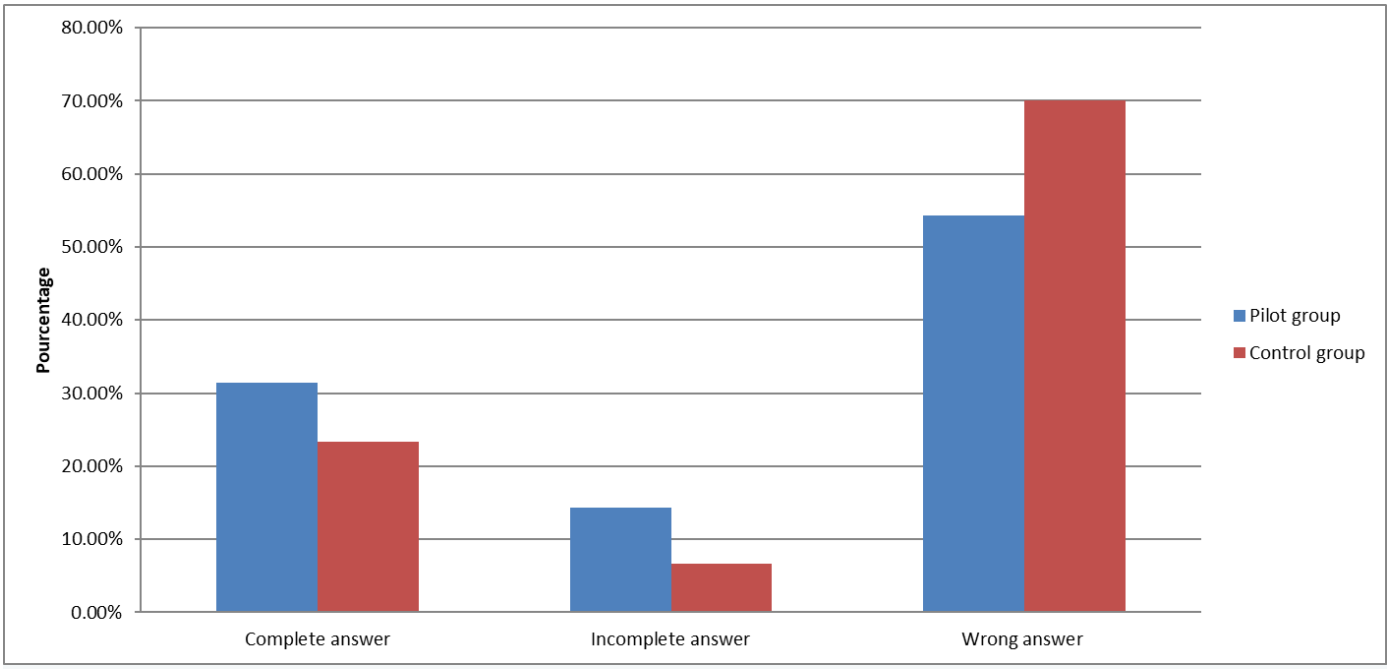

Figure 10. *Student response to the summative evaluation in relation to the role of the liver in storing glucose as glycogen.*

VI- Conclusion

Life and Earth Sciences is an experimental discipline, which aims to develop in the learner a number of skills related to critical observation, comparison, deduction, analysis and interpretation of results... in relation to natural biological or geological phenomena. The experimentation occupies a very important place in this discipline, except that it is not always set up following several constraints met in the majority of the Moroccan schools; such as the lack of pedagogical equipment, the overloading of the classes, the absence of the preparator in the laboratory for the technical support... In front of the present situation, the ICT turns out to be an alternative which will be able to be exploited by the teachers to approach the scientific concepts to the students and to facilitate their comprehension and the realization of a conceptual change at them. The objective of our work was to measure the impact of the introduction of ICT, through videos simulating the phenomenon of blood glucose regulation, on the understanding of students and on the realization of a conceptual change in relation to this scientific concept.

This is why we chose a control group, with which we worked with the classical method; and a pilot group for which we

accompanied the classical method with simulation videos. The results of the summative evaluation showed more mastery in the learners of the pilot group compared to the control group, knowing that the levels of the two classes were close according to the averages obtained in the first semester in the matter of LES; especially when it is about questions of synthesis or linking between several phases of the process of the regulation of the glycemia. This proves the positive impact of this method on the students' learning. Our results accentuate a considerable amount of research conducted internationally (Benfares et al. 2015; Alj et al. 2016). Yet, we cannot overlook a considerable percentage of students who, despite the use of ICT, still rely on their intuitive misconceptions. This proves that conceptual change is a considerable challenge for science didactics (Dunbar et al. 2007), as often intuitive conceptions are erroneous and usually prove to be very resistant to change, especially to formal teachings (Lebaz et al. 2018). These, according to (Tiberghein, 2003), play a key role in the acquisition of knowledge, especially scientific knowledge.

Furthermore, several research works have cited the positive effect of collaborative work on student learning. Potvin and Hasni (2014) find that it has a very interesting positive impact on learners' interest in science. While Morgan (2000), believes that collaborative learning leads to better long-term retention of knowledge. And Eymur (2016) says that it leads to better understanding and disappearance of misconceptions in chemistry.

For this reason, and as a perspective, we intend to spread this experiment over a larger population of students, in relation to different chapters of the LES curriculum, but in a collaborative context. In order to confirm the results obtained in the present work as well as the work of other researchers regarding the impact of the introduction of ICT in a collaborative context on the quality of learning and on the achievement of a conceptual change in learners.

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