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Advantages and limits of the use of ICT in a session of practical work on electricity among learners of the first year of secondary school

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Abstract

In this article we undertook a work of characterization of a teaching sequence in class using a pedagogy involving ICT. It is in fact a question of identifying the advantages and the limits of the latter when learning the concepts of voltage and intensity in electricity for learners of the first year of secondary school. For this, we have adopted a comparative approach between two situations of setting up a lab once without ICT and once with ICT. We asked following each step the same MCQ based fundamentally on the circuits manipulated by the learners during the TP. The results collected and analyzed statistically showed some advantages associated with ICT which can be summarized in two essential points:

-Possibility to offer learners a clear representation of electric current in Ohmic conductors. Their conception of this phenomenon has become more or less realistic on the microscopic scale that experience is unable to offer. This allowed them to clearly distinguish an open mesh from a closed mesh.

-Possibility of better illustrating the electric current than experience for passive dipoles in series or in derivation.

However, we have also identified limits associated with the TIC coming essentially from the macroscopic aspects of the electrical phenomena which can be well illustrated experimentally. For example, the comparison of voltages at the terminals of two symmetrical dipoles.

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1. INTRODUCTION

Over the years, the arrival of multimedia, the increase in computer performance, their ease of use, networking via the Internet and then the marriage between computing and telecommunications have given rise to ICT.

These have been technological leaps that have significantly changed the activity of modern society in information dynamics, collaboration, cultural exchange and even diverse learning.

This metamorphosis undergone by the civilization of the human being in the current state, imposes these laws directly and indirectly in the different areas of life and influences mutations on these different paradigms.

Among these areas, known as the internal engine of the cognitive system of a society, the area of teaching learning which, by virtue of these changes, must benefit from the advantages offered by ICTs to develop new paradigms that can lead to optimal situations. .

However, the integration of ICT in a teaching-learning process is an operation that requires reflection on multiple scales, pedagogical, cognitive, psychological, material and others...

So that these play a role not only in expanding the field of our cognitive, psychomotor and socio-affective skills, but also in contributing strongly to the development of theories and practices in all areas of social life.

For at least two decades, research work has been carried out with the aim of seeing the advantages and limits of the use of ICT in the field of education and to see more closely the difficulties that can arise in their installation.

For example, a study in France dating from 1998[1], carried out by Alin Durey and Daniel Beaufils on the use of computers in the teaching of physical sciences showed that a simulation tool allows, alongside experimental data the exploration of a physical model and the activities of its virtual experimentation constitutes a relevant element in learning in physical science.

Another work carried out in 2003 [2] by Daniel Beaufils and Bernard Richoux on simulation software for modeling in the physical sciences in the context of secondary and higher education emphasized the difficulties encountered by pupils at the of the use of this software, and by the teachers via the optimal pedagogical choice of a modeling tool among several accessible.

In 2006 [3] Francis Bangou tried within a large American university to systematically analyze the interrelationships between the integration of ICTE and pedagogical changes within the framework of a teacher training program. in foreign languages.

A comparison between two teaching devices using ICTE, one in physical sciences and the other in technology, allowed Pascale Brandt-Pomares and Jean Marie Boilevin in 2008 [4] to note that in addition to the change in the way to be taught, the function of these systems must focus on the knowledge taught itself.

In 2011 [5] , a study carried out within the ENS of Madagascar by Harinosy Hanitriniala Ratompomalala where he focuses on the way in which it is necessary to train teachers of physics and chemistry so that they can use ICT in their activities professionals in the classroom.

In Morocco, research in 2018 [6] on the integration of ICT in the teaching of life and earth sciences, enabled an entire research team formed by Youssef Nafidi, Anouar Alami, Moncef Zaki, Bouchta El Batri , Mohammed Elazami Hassani, Hanane Afkar to conclude that all the results of a study conducted among 181 teachers spread over a large number of establishments (colleges and high schools) express a limited use of ICT by the latter in their professional practices , although the majority of them are convinced of the richness of the educational opportunities induced by ICT.

Another study in Morocco carried out in 2021 [7] has just confirmed this last result or out of 125 physical science teachers questioned belonging to three different academies, 94.4% of them express a great interest in the use of ICT in their professional practices, however, only 8% include them on a regular basis in class. In Tunisia, and since the creation of the Virtual University of Tunis (UVT) in 2002, attempts to integrate ICT in higher education have been launched.

We have identified in several research works Allouche & Belcadhi, 2016; Houissa, 2009; Jelmam, 2012; Kaddachi, 2017; Kalai, 2018; Zghidi, 2010, a large number of projects and initiatives for the integration of ICT in Tunisian university education, but few are the subject of documented surveys and analysis and the documentation collected deals in a superficial way practices and uses of ICT by teachers.

The few articles collected do not allow us to envisage a significant representation either of the current state of the use of ICTs or of their contribution to pedagogy.

It was Adel Ben Taziri and Abdeljalil Akari who proposed in 2020 [8] and for the first time a quantitative work leading to an updated portrait of the expertise of Tunisian university teachers in pedagogical practices by ICT while identifying their skills current. In secondary classes, basic school and primary, the integration of ICT in Tunisian education has just begun these first steps.

The difficulties are not only related to the appropriate equipment but also to the empowerment of the teaching staff to exercise professional practices of ICT including pedagogical choices appropriate to their teaching. Admittedly, there are several obstacles hindering the integration of ICT in education in general and that of the physical sciences in particular, but at the same time this change in the educational paradigm deserves to be examined in the field to identify the parameters of its effectiveness and the carried by his contribution.

Indeed, in the absence of experience or concrete references involving the effectiveness of ICT in pedagogy, teachers are always reluctant to invest significant time to the detriment of school programs in activities whose relevance remains to be justified.

It seems clear that the risk of didactic integration of computer objects in the teaching of physical sciences is significant if we do not take into account the harmful effects.

At the same time, Chevallard for his part emphasized the risk that this integration at the level of the teaching of mathematics is incomplete and the results obtained are therefore of low viability.

In this article, we undertook, as opposed to the work of the predecessors who mainly focused on the teacher, a work on the contribution of the integration of a computer simulation tool at the level of a session of practical work. among first year high school students.

It is, in fact, a comparison of the state of learning between two situations, one of which uses a computer tool during a manipulation on the notion of intensity and voltage in circuits simple electrics. The results of this study are obtained through a questionnaire and we have tried to interpret them from a pedagogical, psychological and epistemological point of view.

2. THEORETICAL AND PROBLEMATIC FRAMEWORK

The teaching of physical sciences in secondary classes in Tunisia according to the educational guidelines (Ministry of National Education) in 2010 has the following objectives: To develop in learners elements of scientific culture that will help them to form a rational representation of natural phenomena surroundings and better adapt to the contemporary world;

Acquire a certain autonomy, by becoming aware of the responsibility to act in order to learn and by developing the spirit of creativity; Systematize the practice of the scientific approach by the frequent implementation of these stages (position of the problem, formulate hypotheses, use experience, documentary or field research to confirm or invalidate hypotheses put forward, conclude or deduce …).

At the same time, the official program insists on teaching students to mobilize knowledge, know-how and interpersonal skills in an integrative way in authentic problem situations triggered by physico-chemical phenomena.

Apart from the orientation of the pedagogical strategy towards a path that emphasizes centering the contents of teaching on the essentials and identifying a fundamental base of declarative and procedural knowledge; to strengthen the interdisciplinary correlation by the possibility of offering students a rational and global vision of the natural environment and introducing them to rigor and the scientific method; it insists on strengthening the mastery of information and communication technologies (ICT) through classroom practices and individual practices.

Indeed the accelerated pace of technological development worldwide calls for the renovation of education systems so that they can improve the quality of teaching and learning.

Adapting to modern life requires knowledge and know-how vis-à-vis the different domains of human activity and the lessons are subject to meeting these specifications.

In this regard Guttmann (2003) as well as other observers, perceive ICT as means capable of responding to many challenges within various learning processes.

In physical sciences, computers in particular make it possible to visualize phenomena, to simulate an experience, to draw curves from tables of values... Besides that, it has been demonstrated in many previous works that ICTs are real allies of teaching because they modify the teacher-student pedagogical relationship and change the relationship to knowledge (Deveauchelle 2012).

They also allow the development of disciplinary skills and also that of cross-curricular skills.

Klein (2013) confirms that apart from the psychological effect generated by digital technology which reinforces the motivation of the learner, the latter profoundly modifies the strategies of students to learn, and of teachers to teach.

In this theoretical framework where we use pedagogy, psychology and epistemology, we try to characterize a learning situation of the physical concepts of tension and intensity during a practical work session.

Our problem lies at the heart of pedagogical practices in the classroom using ICT and it revolves around the following points:

- Obstacles linked to the integration of ICT in practical work sessions.
- Added values of ICT in terms of pedagogy and the effects on motivation and on learning itself.
- Limits of the use of ICT compared to a physical science practical work session.

3. METHODOLOGY

This study is conducted with learners of the first year of secondary school (who are 30 students) during a practical work session on the concepts of electrical voltage and intensity.

The students come from the Mohamed hedi Ammri-Kalaa Sghira-Sousse high school.

The approach followed is as follows: in a first step we attended the practical work session led by the physics teacher. The proposed experiments aim a priori to consolidate the concepts of voltage and electric current and their underlying properties already developed during the course.

By limiting itself to the framework of the official program [9] which clearly sets the objectives for teaching the concepts of voltage and electric current and also defines the capacities required at the end of the associated practical work.

We undertook a work aimed at characterizing the quality of learning during an electricity practical work session using an ICT means compared to another practical work without ICT.

After having finished the experiments proposed during the TP, we proposed a MCQ for the students.

The next session we proposed to visualize these same experiments using simulation software (Interactive Simulations for Science and Math PhET free on the internet, https://phet.Colorado.edu/) mounted on a data show.

The students presented themselves together in a room and each time a student manipulates an experience virtually. At the end of the session we proposed the same MCQ.

The results comprising the answers of the pupils are welcomed and explored quantitatively in percentages on the various possibilities envisaged for each question posed in the MCQ.

By a comparative analysis, we try to identify the advantages and the limits of the introduction of simulation in the learning during this practical work of electricity.

In addition, it should be noted that the correct answers of the MCQ were not evoked in front of the pupils for the two scenarios and the values of the percentages declared are approximate in a confidence interval of length equal to unity.

4. RESULTS AND DISCUSSIONS

In this part of this article we propose to present the scientific content of each MCQ question, the results received from the students' answers and the comparative analysis and discussion as they go along.

Question (I) of the MCQ aims to identify a voltage and an electric current in a mesh and this using a circuit comprising only a lamp, copper wires and one or two generators. The pupils are led to prepare four circuits (A), (B), (C) and (D) from which they can distinguish with the naked eye the one where the lamp is lit. The only situation where the mesh is closed is that of the circuit (C) and the statistics on the electric current of the first question (I-1) of the MCQ show that at the end of the manipulation 90% of the pupils checked the answer just (C) while the rest was split into two 5% packets while checking off possibilities (B) and (D).

On the other hand, we recovered 100% of responses (C) after the presentation of these four circuits using the simulation software mentioned above. If we make the assumption that the prior knowledge of the learners comes from the course but also from common sense because at home the presence of electric current is tested by lighting a lamp (physically admissible sense), we would have had 100% response (C) at the end of the experimental work and yet this is not the case compared to the results after the simulation.

This can be explained by the fact that some students exert an effort to mentally simulate the nature of the electric current via the ideas acquired from the course and undergo a cognitive upheaval which makes them lose concentration on the different responses.

On the contrary, the simulation by the software clearly shows the nature of this current and only appears in the circuit (C) which induces 100% of the students to the correct answer. However, the question (I-2) concerning the voltage simulation led the students to answer 100% the possibility (C) against 90% at the end of the experiment.

While the concept of voltage is difficult to introduce independent of current to first year secondary learners without using a voltmeter, the confusion that voltage can only exist in a closed mesh was reinforced by the simulation compared to the experimental which explored 10% of pupils towards other possibilities.

Question (II) of the MCQ aims to illustrate that a lamp consumes electrical energy as opposed to common sense (consumption of electrical current), it is in fact a question of removing an epistemological obstacle by breaking with the unscientific sense.

The pupils are led to create an electric circuit comprising a voltage generator, copper electric wires and a lamp. When the mesh is closed and the lamp is lit, the pupils test the presence of heat when touched by the lamp compared to the situation of the latter when the circuit is open.

At the end of these observations, the answers of the pupils to question (II-1) of the MCQ favor 80% in the scientific sense that the lamp consumes electrical energy against 20% in disagreement with this sense.

The simulation with the software resulted in 95% with the physical sense against 5%. The 15% increase towards the scientific sense is attributed to the possibility of representing the lamp as a resistive dipole (Introduction inside the diagram of the lamp a resistor) induced a little more correct answers via the previous knowledge of the students that a resistor consumes electrical energy.

This possibility is not offered by the experiment because the lamp represents for the pupils at this level of study a black box therefore not recognized from an electrical diagram point of view.

As for question (II-2) and represents common sense, we got 60% correct answers at the end of the experiment against 94% at the end of the simulation.

The virtual experience favors the correct answer that a lamp does not consume electrical current, it is rather electrical energy because the simulation of the circuit clearly shows the same flow of charges which circulates in the circuit upstream and downstream of the lamp which allowed students to make a kind of epistemological break with this common sense.

Question (III) aims at two essential points. The first is the illustration of the current upstream and downstream of a receptive dipole and the second is the illustration of the symmetry of the voltages in relation to the symmetry in the circuit.

This objective is pedagogically implemented through the circuit of figure (3) in the QCM comprising two identical lamps, a resistive dipole, a voltage generator and copper connection wires.

After having finished with the experiment, we posed the question (III-1) and we collected the answers which are distributed on 94% of right answers and 6% for a wrong answer whereas after the simulation we collected 100 % of correct answers.

We note that the difference between the two situations of the order of 6% is not significant enough to be able to attribute a real advantage associated with the presence of the software.

Indeed, a lack of concentration in the experimental or a bad choice of the voltage of the generator (quite low which gives a low luminosity of the lamps) which leaves a small number of statistically insignificant pupils to offer a false answer.

The confirmation of this observation comes with the questions

(III-2) and (III-3) where we modified the value of the resistor inserted between the two lamps and we collected respectively for (III-2) 99% correct answers at the end of the experiment against 100% after the simulation and for (III-3) 100% correct answers in both cases.

The finding for the students that the two lamps are traversed by the same current was clear in the experiment before the simulation from the moment they observed that the two lamps lit in the same way and the simulation was only confirmed there.

Also by comparison with the experiments of questions (I) and (II), the students found that the voltage across the terminals of lamp L1 is equal to that across the terminals of lamp L2.

Question (IV) addresses the properties of shunt currents, the proposed circuit comprises two resistors connected in parallel and are subjected to the same voltage delivered by a generator (see figure 4).

There is also an ammeter to measure the current in each branch upstream and downstream of each of the resistors.

After attending the experiment and also the simulation, the students were questioned by the question (VI-1).

The results collected showed that 80% (respectively 83%) of the pupils ticked the correct answer to question (IV-1) (respectively for question IV-2) and this after the manipulation.

On the other hand, we obtained 100% of the students who ticked the correct answer for the two questions after having attended the simulation of the circuit by the software.

Following the example of these results, we can conclude that the illustration of the electric current in the form of a displacement of flow of loads well observed in the two branches and also inside the resistances, and the flexibility in the choice theoretical values of the latter left no chance for the pupils to be mistaken in the comparison of the currents of the two branches.

On the contrary, during the experiment, the milliammeter must be connected once in series with and once in series with and each time the value of the current is noted and it is up to the students who must carefully follow the measurement protocol without appeal to the role actually played by the measuring device.

Otherwise if the measuring device is crossed by this current or not if we refer to the fact that these learners see the situation for the first time.

So we see that the manipulation of a more or less complex electrical circuit (two meshes and many connection wires) requires a longer concentration time and a significant duration of manipulation to arrive at assimilation.

The role played by simulation using software is to considerably reduce this assimilation time and to give a good representation of the phenomenon; it is in fact a complementary role.

The main objective of **question (V)** is to illustrate a characteristic of an electrochemical generator (battery) which is the link between its lifespan and the value of the current it delivers in a purely resistive load.

For this we have proposed the two circuits of figure (5) each comprising two identical lamps, copper connection wires and a battery.

The two batteries are identical and the two lamps are once connected in series (Fig A) and once in parallel (Fig B).

As a result of the manipulation, we have asked a single question (V-1) which will relate to which of the batteries which maintains a voltage for the longest time possible in the circuit.

The results collected show that at the end of the experimental manipulation 70% of the pupils ticked the correct answer, whereas after the visual simulation using the software, almost 100% of correct answers were obtained.

While during the manipulation the two lamps in the circuit (A) appear less luminous than those of the circuit (B), some of the pupils found it difficult to make the link between the luminosity and the current delivered by the generator that at least qualitatively.

It is reasoning sought at the level of the pupils by this question that it had to be designed mentally based on the achievements of previous experiences.

The elongation in relation to this reasoning generates a cognitive obstacle against the scientific sense that the life of a battery is linked to the value of the intensity of the current that it debits in a load.

This obstacle is completely removed through simulation where we have the ability to visualize the electric current as a flow of charges in both cases and the students can easily compare the current intensities delivered by each battery.

At the end of this work, and apart from the pedagogical advantage linked to the use of software for simulating electricity experiments and which has been proven in this study, we have noticed that on the psychological side, the pupils were well motivated to use the software.

This motivation has induced quite often a socio-cognitive conflict on the concept of electric current and especially on the spherical model of representation of electric charges.

Some students also wondered about the cause of displacement in the charges inside the circuits, something that the teachers had never experienced before when they were asked the question.

Alongside these advantages, we have identified some limitations in the use of this means of ICT and which are on the one hand specific to this type of experimental practice and on the other hand linked pedagogically to the capacities and options of the software to be presented. the phenomenon.

In addition, we have identified difficulties related to the use of these ICT means in pedagogy coming from the logistical side (PC simulation equipment not available) and from the teacher training side which is still limited and requires activation.

5. *CONCLUSION AND PERSPECTIVES*

The quantitative study that we conducted with first year secondary students on the advantages and limits of the pedagogical use of ICT in the teaching of practical work in physics, particularly during a practical work in electricity, led to the summary of the following main results:

- The illustration using a simulation of a physical phenomenon on a microscopic scale such as the case of electric current can really offer a realistic representation of the phenomenon for students who are new to learning the concepts of physics.

Indeed the conception of the pupils on the electric current remains limited even at the university and the ICT can be in this case effective teaching means to better learn these concepts.

- The simulation of a physics experiment using software makes it possible to explore certain phenomena hidden by the experimental devices which helps a lot in the understanding and assimilation of students of certain laws and concepts of physics and particularly in electricity.
- The use of a means of ICT stimulates the motivation of learners, and can induce the minds to questioning via socio-cognitive conflicts.
- ICT can play a complementary role to experience and can offer not only learners the possibility of developing optional skills on computer hardware and on simulations in general, but also for teachers of pedagogical, scientific and good time management.

- Symmetrically to the advantages related to ICT identified during this study, we have identified factors limiting the use of the latter in the teaching of practical work which are of a logistical nature (materials not available) and institutional (training of the teaching staff).

In the end, it seems very relevant to us to continue this work in this area of research and to focus on the added value of ICT in terms of the choice and development of physics experiments by comparing the different teaching devices used such as the form of the animation of the phenomenon, the choice of relevant associated parameters, the exploration of measurable physical quantities, etc.

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