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# PLACE OF EXPERIMENTATION, SIMULATION AND COMPUTER-ASSISTED EXPERIMENTATION IN PHYSICS TEACHING

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**Abstract-** In 2005, an ICT component (GENIE Program) was integrated into the initial training of future physics and chemistry teachers at the regional centers for education and training professions CRMEF, Morocco. The question that arose was then: "how to best prepare teachers to use ICT in physical and chemical science experiments while exploiting the true potential of computer-assisted experiments (CAEx) and digital simulation to reveal some invisible phenomena to the naked eye?". Answering this question within the framework of field research was a main challenge of our work. This research was carried out on qualifying secondary school teachers of the target subject at the provincial directorate of Moulay Rachid - Sidi Othmane, in the Casablanca - Settat region. At the same time, we were interested in training teachers in the effective use of ICT in the classroom through various international reports and research articles. Despite the contrasts due to differences in equipment, training, generation between the establishments and teachers visited, it seemed useful to us to analyze the practices of physics chemistry teachers linked to the use of ICT, in order to find elements to fuel our action research. The results led us to realize that the place of digital simulation, as well as that of CAEx, is still important, alongside scientific experience, without having to replace it.

**Keywords:** ICT, Digital Simulation, CAEx, Education, Physics, Chemistry.

## 1. INTRODUCTION AND PROBLEM

Morocco started reforming its educational system in 1999 by putting the national education and training charter into practice in order to integrate into the global information and knowledge society. The use of modern information and communication technologies in education (ICT) has been given its own lever in this charter (Lever 10 [1]). An ambitious initiative called GENIE - Generalization of Information and Communication Technologies in Education in Morocco - has been created in light of this. The GENIE Program Directorate has introduced a new strategy to promote, facilitate, and highlight an educational culture that favors the integration of ICT in teaching and learning. The strategy aims to materialize the ministry's policy with regard to the effective integration of ICT into the teaching practices of teachers.

ICT are a crucial component of both our society and the classroom. ICT also offers a lot of benefits for everyone's success. These results ought to motivate ICT integration in education stakeholders' minds. The use of ICT in scientific education provides an endless supply of resources for educational practices and instructional materials. In secondary school, the investigative technique is crucial for improving the effectiveness of studying the physics-chemistry curriculum. Incorporating ICT into this strategy in a particular way would enable it to get over some challenges that are unique to studying this difficult and abstract field. After assessing the terminological ambiguities that the acronym TIC (Hornung-Prahaser and Geser, 2010) implies. Dawson, Forster, and Reidd (2006)) mentioned by Baron and Bruillard (2008), the CAEx type usage in the laboratory, modeling, and data processing have been categorized as the specialized uses of ICT for teaching physics and chemistry (Cox, 2012; Beaufils, 2005; Bryan, 2006) [2].

The digital simulation (Cox, 2012) was initially based on real experiments beyond the scope of laboratory possibilities: predator-prey, satellite movement, global warming, river flows, traffic, etc. They do not require the use of advanced mathematical tools, and can replace real experiments, with the advantage of the possibility of repetition, of the instantaneous change of certain parameters with a view to their analysis [3]. Physics and chemistry teachers are currently required to use ICT (digital simulations or CAEx) to prepare their students for experimental skills tests. Indeed, without replacing real experimentation, ICT can support the experimental approach (EXAO, Simulation, etc.) at different moments of the process in order to motivate learners, facilitate the

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passage of information and resist the constraints of the laboratory [4]. ICT allows added value for the experience but future challenges concerning emerging technologies and the development of teaching methods have highlighted the importance of taking this tool into consideration.

## 2. PROBLEM SOLVING

The invention of the computer and its widespread use have altered the nature of education. According to Andrew Molnar (1997), modern information and communication technology - particularly computers and the internet - is tied to and increasingly dependent upon it. However, adopting and integrating ICTs at all levels and in many forms of education will be an incredibly tough task due to the existence of the Digital Divide - the divide between those who have access to and control over technology and those who do not. The information gap and the current stark economic and social difference will get wider if the problem is not fixed [5]. Nearly every element of modern life has been touched by technology, and education is no different. But is it? In some aspects, schooling appears to be largely unchanged from many years ago. There are only a few minor aspects that have changed (the material is the same, but the teaching/learning process has improved). In fact, there has been discussion and disagreement on the viability of employing modeling with younger pupils (Tytler & Peterson, 2004).

Regarding whether simulations are a type of experience, a theoretical or intellectual instrument of analysis, or a way to bridge theory and experience to learn more about the nature of things, scientists and epistemologists cannot agree (Parrochia, 2000; Varenne, 2006). Before incorporating a technology into our classes, we must take into account its dependability, efficacy, and impact on our educational system.

Under the regional guidance of Moulay Rchid-Sidi Othman, computer aided experimentation and simulation have recently emerged as a helpful instrument in the teaching of certain precisely scientific subjects for students in the third year of secondary level classes. This is particularly true at the microscopic level (atomic rearrangements, atomic models, charge carrier displacement, etc.) or at the level of hazardous, explosive, or sluggish reactions. In the teaching of chemical sciences, how useful are simulation and computer-assisted experiments (CAEx)? is the straightforward issue this work seeks to resolve.

From the central query, several additional questions can be derived:

- How can we best prepare teachers to use ICT in physical and chemical science experiments while exploiting the true potential of computer-assisted experiments and digital simulation to reveal some phenomena invisible to the naked eye?
- What is the contribution of simulation and CAEx to experiments in physics and chemical sciences?
- What is the difference between simulation and CAEx in terms of performance and efficiency?
- Can simulation and CAEx really replace experience?
- Can we say that simulation and CAEx close to reality?

## 3. LITERATURE REVIEW

Teaching and learning of scientific concepts are not happening always as easily as we would like. Several difficulties are encountered at various levels: vocabulary and symbols (mathematical and others), difficulties conceptual concepts, the teaching methods used and the diversity are just a few examples (Thouin, 2002; Astolfi et al., 1997; Brook and Wells, 1988). Furthermore, many scientific concepts are abstract. It is at this moment to use a progressive approach which begins with concrete material and moves towards abstract material. This progression will make it easier for students to understand the concept (Thouin, 2002; Abide, 1972). Furthermore, according to Aylwin (1992a), the concrete must precede the abstract. "We can only do abstraction work from the concrete" (Aylwin, 1992a).

A clumsy manipulation is not really harmful, a poorly written letter is not a reason to refuse hiring, and a miscalculation does not damage someone, as proved by Olivier Reboul (1980) in the philosophy of education. School difficulties are life problems, but they don't have the same outcomes. The driving school is only required because driving errors do not result in accidents (P.10) [1]. Since the 1960s, modeling and simulation have been extensively studied within the context of scientific and technological education (Giordan and Martinand, 1987). Drouin (1992) discovered the earliest publications on science modeling and included over 250 references related to scientific didactics, cognitive psychology, or epistemology [3]. The simulation seems to grow needs for graduates to be operational or even employable. (Discover how to transition from job analysis to professional growth through simulation. Pierre Pastré, from 2005.

Users might mistake a simulation of a real phenomenon, according to Hebenstreit (1992). Richoux, et al. (2002) contend that reality and theories must be properly distinguished in order to prevent such a risk. According to these authors, simulation can be viewed in this way as an intriguing middle ground that helps bridge the gap between reality and theory [6]. We face the danger of pupils forgetting about these extra aspects since Mark (1982) points out that simulations must exclude some factors. According to Thomas and Hooper (1991), The simulations contribution is ambiguous or questionable in some circumstances. In fact, if the student is unable to solve the problem, he is unable to determine which elements of his model of system are incorrect [6].

## 4. THEORITICAL FRAMEWORK

The components of a CAEx typically consist of a sensor (such as a motion sensor or magnetic field sensor) that produces a measurable physical quantity (such as an electrical current or voltage, a pressure, the strength of the magnetic field, etc.), an acquisition interface (such as an analog-digital converter), and a computer that can process the measurements using specialized software

(Figure). This method has been used extensively in video-mechanics since the 2000s, when they first created a mini-film using a camera to calculate an object's position, speed or acceleration, and kinetic, mechanical, or mechanical energy. Data acquisition systems are tools or procedures that gather data in order to describe or examine a phenomenon.

In Northern European nations, such as Finland, 90% of instructors report utilizing digital tools, usually for personalised learning purposes. The use of modern communication and technical tools by teachers is most pervasive and substantial there. there are several types of sensors that can be used for ExAO experiments in physical and chemical science classes in qualifying secondary schools, such as: voltage sensor, electric current, teslameter, temperature, sound level meter, pH, force and pressure sensor, etc. According to a 2008 Ministry of Education survey, 64% of French secondary school instructors utilize ICST. In accordance with the 2011 Profetic study conducted by the French Ministry of Education (MEN-PROFETIC, 2011), 77% of teachers utilize ICT with their students at least once a week.

## 5. METHODOLOGY

This study is carried out in provincial directorate of the Ministry of Education and National Training; Sidi Othmane and Moulay Rachid, in Casablanca-Settat regional academy. The rationale behind selecting these paths is to aid in the research process. The study's target audience consists of one hundred certified physical science instructors in secondary schools. We gathered their thoughts using an anonymous questionnaire with closed questions to find out how they felt about the employment of CAEx in the teaching of physical sciences and how this teaching related to the development of certain talents in students. Excel software was utilized to process the outcomes.

The following axes are included in the questionnaire: General information:

- Simulation uses in class.
- ICTs integration in course.
- Experiments and CAEx's use.

## 5. RESULTS AND DISCUSSION

### 5.1. Teachers' Use of Animation Flash, Video, Image and Simulation

Analysis of the survey's results (Figure 1) also revealed that the majority of ICT-integrated instructors employ simulations (66%), animations (66%), videos (72%), and photos (70%), in their lessons. Given the nature of the subject, they can be used to complete the experiment in the absence of materials or suitable conditions for conducting experiments. They continue to be quick solutions for obtaining and using the measurement results in a short time, and they don't require much preparation time (in reality, neither simulation nor videos can replace experiments, no matter how good they are). However, they shouldn't be used to replace actual experience, if possible.

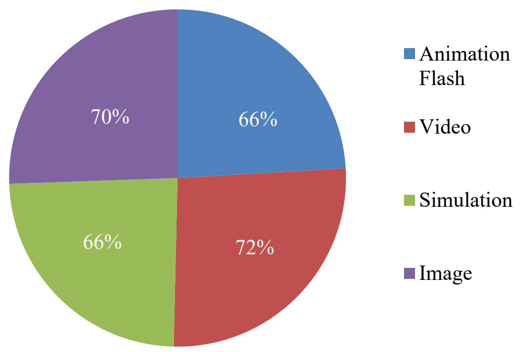


Figure 1. Teachers' use of animation flash, video, image and simulation

### 5.2. Frequency of CAEx Use by Teachers

Contact with living humans, using tools and procedures, and being aware of the intricacy of nature via genuine experimental manipulations are vital. Rather than conducting actual experiments in class, we will mimic those that are too costly, complicated, risky, etc. However, if a digital simulation, flash animation, or film of a practical experiment eliminates the repeating of tiresome routine processes, the simulation may be used in conjunction with the real task itself (as shown in Figure 2). Since video may be more realistic for pupils, carries fewer dangers, and is still an option if there are no items or resources available, most professors prefer it over simulation.

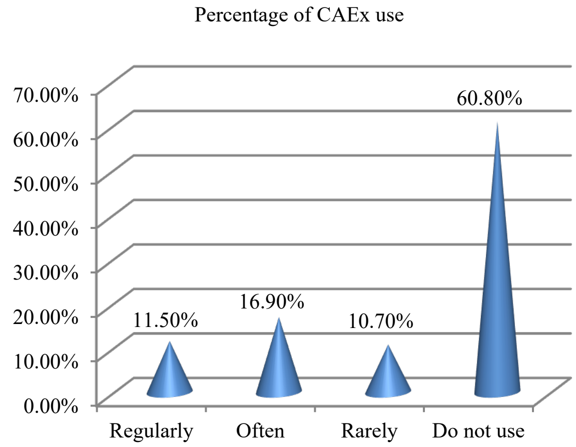


Figure 2. Frequency of CAEx used by teachers

Given the importance of CAEx and the use of educational software in physical sciences courses, most of the teachers (83%) surveyed request additional training from experts, in order to improve their teaching methods and ensure proper integration of ICTs in the classroom. Some request complete training in videos animated by the Educ'images association, in order to set up an educational scenario. Others are interested in creating educational websites to make information easier for their students. To do this, it is necessary to increase the duration of the training and specify the training in ICT, by varying the courses: Computer-assisted experimentation (CAEx), Excel, Simulation, Photo (or video) editing.

Recent research showed that that around 48% of students still rely on this strategy for learning. On the other hand, around 78% of students prefer practical situations and about 82% solve problems. In addition, around 80% of students carry out a verification and self-analysis which requires intervention of CAEx and digital simulations [7].

### 5.3. Comparison of Experimentation and CAEx

Table 1 shows CAEx can be an effective tool in terms of effort, time and curve tracing, CAEx is still an experiment but it is being upgraded, given the digital transformation that has undergone the world of education.

Table 1. Comparison of experimentation and CAEx

| | Experimentation | CAEx |
|---|---|---|
| Time | Normal | Fast |
| Effort | High | Modest |
| Curve and table tracing | Slow | Fast |
| Calculation | Slow | Fast |
| Data entry | Slow | Fast |
| Precision | High | Need adjustment |

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### 5.4. Importance of Digital Simulation in PCS Teaching

A multiple-choice test called the ICC (Inventory of Chemical Concepts) can be used to gauge the level of pupils' erroneous notions about chemistry. The inventory comprises of a maximum of 22 one- or two-level conceptual non-mathematical questions. The exact ideas of the pile and how it functions are related to each erroneous response for each question, and these ideas are utilized as methods to assess conceptual comprehension.

Table 2. Comparison of group results

| Questions | Control groups | | | Experimental groups | | |
|---|---|---|---|---|---|---|
| | G 1 | G 2 | G 3 | G 1 | G 2 | G 3 |
| Q1 | 17% | 14% | 20% | 18% | 30% | 16% |
| Q2 | 59% | 58% | 60% | 83% | 84,5% | 81,5% |
| Q3 | 57% | 59% | 61% | 82% | 84% | 83% |
| Q4 | 55% | 60% | 62% | 85% | 84% | 84% |
| Q5 | 61% | 57.5% | 60.5% | 83% | 84.5% | 81.5% |
| Q6 | 70% | 54% | 56% | 88% | 88% | 94% |
| Q7 | 50% | 45% | 46% | 53% | 48% | 60% |
| Q8 | 51% | 45% | 45% | 52% | 50% | 62% |
| Q9 | 77% | 60% | 43% | 91% | 91% | 88% |
| Q10 | 50% | 45% | 46% | 53% | 48% | 60% |
| Q11 | 51% | 45% | 45% | 52% | 50% | 62% |
| Q12 | 56% | 52% | 50% | 55% | 60% | 64% |
| Q13 | 62% | 58% | 60% | 93% | 90% | 87% |

To compare data from the 2 groups and to perform numerical simulation, we used descriptive method to examine the data from this research. According to this study, students who had digital simulation training scored higher on average for questions Q1, Q2, ..., and Q13 than the control groups. The two groups' standardized learning gains differ in a statistically highly significant way (p 0.05). Additionally, we found a significant correlation connecting utilizing simulations and achieving targeted skills (p 0.05), indicating that "simulation integration" is connected to "targeted skill development," which accounts for the superior performance of simulation-using students. The table below shows the different success results obtained by the test among the six groups.

#### 5.5.1. Obstacles and Brakes on the Use of ICT Extrinsic Barriers

- Lack of numerical equipment and maintenance;
- Lack of internet access (only 30% of establishments visited have an internet connection);
- Insufficient ICT training (only 10% of the teachers questioned are satisfied), and it does not meet the needs of physical science teachers.

#### 5.5.2. Intrinsic Obstacles

- Absence of oriented and supervised use (research activities, exercises, courses, projects, etc.);
- Absence of desire.

#### 5.5.3. Infrastructure Barriers

- Lack of permanent technician in the establishment (100%);
- The equipment is not sufficiently reliable, there is always a risk of breakdown in the presence of students (82%).

#### 5.5.4. Barriers to Support and Professional Development

- Insufficient training of teachers in ICT (30 hours);
- Lack of self-confidence.

### 5.6. Levers to Enable the Use of ICT

Almost all teachers (96%) reported that a video projector in the SPC classroom is a necessary condition for using ICT. Some (3%) think that the presence of an interface is also necessary [8]. First of all, we must insist on the training of teachers by motivating the oldest (Some think that it should be made compulsory 8%, others think that the training should be paid 4%), and install the necessary equipment (multimedia rooms, computers, video projectors, interactive whiteboard, etc.), then support teachers in its use [9].

Recent researchs showed that that around 48% of students still rely on this strategy for learning. On the other hand, around 78% of students prefer practical situations and about 82% solve problems. In addition, around 80% of students carry out a verification and self-analysis which requires the intervention of CAEx and digital simulations [7]. Mostly 89% of students think that experience helps them understand the theory [10]. The majority of educators (87.5%) think that while technology can be a supplement to meet the desired educational objectives, it cannot completely replace traditional experimenting activities. [11]. Almost all recent research reveals that ICTs (CAEx and digital simulations) are powerful, effective and essential tools for teaching physical sciences [16-30].

Build a new program and curriculum based on the use of new information and communication technologies and showing their usefulness, so that students can understand what it means to integrate it, get used to it and then use it or help to use it (some prefer that ICT should be used only by teachers, as it requires certain skills [12]. Others see that some very talented students can easily learn to use ICT, see using computers and tablets today.

We can all agree on this new generation of teachers and the student will not hesitate to use ICT for their ability to adapt and open up to new technologies and its tools [13]. At the end of the conference, the UNESCO Declaration on ICT and Education adopted in 2015 in Qingdao. The 22 points of the declaration reflect the principles, objectives and recommendations for the relevant use of digital tools in education [14, 15].

- Involve the school in the teaching of ICT, the knowledge and use of which are essential in today's world.
- Harness ICT to promote inclusive, equitable and quality education and adopt a continuous learning process.
- Evaluate the potential of free software with a view to democratizing and developing access to knowledge.
- Ensure the development of skills in the use of ICT in primary and secondary cycles.
- Ensure the development and continuing training of ICT education stakeholders.

## 6. CONCLUSION

Teaching and learning of scientific concepts are not happening always as easily as we would like. Several difficulties are encountered at various levels: vocabulary and symbols (mathematical and others), difficulties conceptual concepts, the teaching methods used and the diversity are just a few examples. Furthermore, many scientific concepts are abstract. It is at this moment to use a progressive approach which begins with concrete material and moves towards abstract material. This progression will make it easier for students to understand the concept. The concrete must precede the abstract. "We can only do abstraction work from the concrete".

For that, and to ensure the smooth running of scientific experiments in physical and chemical science classes in qualifying secondary schools, it is preferably to remove the previous obstacles and opt for changing educational practices, particularly through the involvement of individuals in a dynamic of change by adopting the project approach to accelerate the exploitation of ICT. It would now be necessary to think about planning at the local level, the moral and material recognition of successful initiatives, the evaluation of achievements (by sanctioning successes and failures) by the councils and authorities concerned and exploit the potential / contribution that offers ICT and digital simulation in SPC teaching.

According to the results obtained, ICT and digital simulation can bring multiple benefits, on the one hand they ensure:

- Diversification of teaching tools and methods;
- The request for visual aids;
- Effectiveness (Remember that learners who were trained using simulation obtained better grades compared to control groups);
- Have a vision as close as possible to what is happening on a microscopic scale;
- Temporal gain;
- Motivation;
- Interactivity;

We would like to study the impact of other digital tools (Interactive whiteboard, CAEx, Platform: E-learning or Distance Teaching, etc.) on learning. Finally, we wish to complete this research with comparative studies of digital uses among different audiences from different cycles (primary or university) and different subjects (SVT, Math, etc.) in the same (or other) region, and/or measure the rate of integration of ICT to finally be able to know if the obstacles previously reported are specific to the subject taught, (or to the region), or not, and if there are other ways to change the current situation of towards a better future, in which ICT will finally be integrated in an educational way and that the learner is actively involved in all teaching - learning activities in class.

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