Teaching Concepts of Electricity and the Related Terminology by Means of Computer Simulations

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1. Introduction

The introduction of Information and Communication Technology (ICT) in education has certainly caused rapid changes in the way most subjects are taught, especially science. [1], [2]. Research over the last few decades has shown that the use of virtual manipulatives, particularly the use of interactive computer-based simulations, has a positive impact on both the cognitive and the affective domain [2], [3], [4].

In recent years, research interest in the teaching of science has largely focused on the detection of the ideas that students have for the concepts and phenomena of science, which has resulted in the existence of a considerable international literature in this area. Research in science education has shown that difficulties in understanding scientific concepts are widespread across all ages and levels [5]. Students of any age come to science classes with ideas/ conceptions that differ fundamentally from scientific conceptions in specific domains [6]. The primary reason behind this discrepancy is the fact that students over many years of experience in their everyday world have already constructed their conceptual knowledge about the physical world, their interpretations for science terminology, as well as some quite reasonable explanations for how and why things function, [7].

In general, these constructions are usually not consistent with scientifically accepted ideas [8]. Researchers use different names for these scientifically inconsistent ideas, namely preconceptions, misconceptions, alternative conceptions, intuitive conceptions, and so on [9], [10].

Students' ideas and interpretations, based on everyday experiences and language, often interfere with the learning of the scientific models introduced during science classes and affect the ability of the students to assimilate the scientifically correct ideas [11],[12],[13],[14],[15]. This finding suggests a need to refocus our efforts on ways of promoting conceptual understanding through meaningful learning experience which embraces students' worldviews in a way that promotes assimilation of the scientifically accurate conceptions [16].

Researchers suggested that conceptual understanding is only accomplished through learning that promotes conceptual change [17], [18]. Piaget (1985) argued that, in order to foster conceptual change, students have to be confronted with 'discrepant events' that contradict their conceptions and invoke a 'disequilibration or cognitive conflict' which puts students in a state of reflection and resolution. Research has shown that these discrepant events and meaningful experience could be provided effectively both through the use of laboratory inquiry-based experimentation [1] and through the use of virtual environments that support experimentation, such as interactive computer-based simulations [4], [7], [19].

In other words, there is considerable research showing that students face difficulties and have developed alternative ideas to the understanding of electrical circuits and, generally, electricity [7], [20]. The first contact of the children with the electricity is through the use of household appliances. For example, several students exhibit verbal confusion about the notions of 'open - closed' electric circuit or switch [7], [20]. Other students fail to understand the need to connect both poles of a battery to light the bulb.

Based on these data, the present study aims to teach students in an innovative way concepts of electricity and simple electrical circuit through the use of Information and Communication Technology (ICT) and, especially, by means of simulations, so that students will be able to change or modify any misconceptions they have about specific notions of electricity [20], [21], [22]. Therefore, through the use of Web 2.0 tools and the proper use of the relevant terminology, we set out to improve the learning outcomes as regards specific concepts of electricity.

2. Alternative conceptions or intuitive conceptions for electricity

Earlier studies naturally have dealt with identifying students' alternative conceptions related to electricity. For example, Fredette and Lochhead (1980) found that most young students consider that current can be carried by a single wire from the positive terminal of the battery to a bulb to illuminate it and thus there is no need to connect another wire from the battery to the bulb. However, some

students consider that current coming from the positive and negative terminals of the battery should be met at the bulb to illuminate it and therefore they consider that two wires are needed [10].
At the same time, in similar investigations, verbal confusion that exists in a number of students on the 'open - closed "electric circuit (or switch) demonstrates that daily-practice knowledge continues to be supported by them, as it is highly functional and helps them give satisfactory (from their perspective) explanations in the context of their daily life (open switch - lights the bulb, turn off the switch - turns off the bulb). The scientific use, however, the "open - close" switch gives different content and meaning than the every day use of the term , which poses problems for students in the process of learning the notion of "open-closed" electric circuit by the use of the switch, the result being that students are not able to connect these two kinds of knowledge (i.e. every day – scientific) [7].

3. Objectives of this paper

The objectives of this paper are:
a) to detect the alternative ideas that students have in the area of electricity and find the linguistic confusions that lead to the incorrect use of relevant language (i.e. terminology)
b) through the use of simulations and linguistically appropriate activities, we attempt to change student alternative ideas on electricity and teach them the scientifically sound concepts and notions.

4. Methods

4.1 Sample

The sample of the research was 28 students of 5th and 6th grade of primary school. 13 students were in the 5th grade, while 15 students were in the 6th grade.

4.2 Experimental design

For the implementation of the experimental intervention, this research used a method divided into three stages:

a) pre-test: students were given the original worksheet as a pre-test aiming at detecting the alternative ideas that they possibly have on electricity. From the analysis of the data it was shown that the majority of students have two basic alternative ideas: i) students felt that the lamp can light up only one pole of the battery, ii) they confuse the closed or open electric circuit with the "open" or "close 'light.
b) the simulations: This stage is divided into two sub-steps. These include: i) the predictions /assumptions found in worksheet (2) and ii) the confirmation or rejection of the predictions/assumptions – through the execution of the simulations and the use worksheet (3) - Experiments
c) post-test: students were given a worksheet as post-test aiming to test whether their alternative ideas were changed.

The above intervention took place in 2 teaching sessions for each grad (5^{th} and 6^{th}) without any interruption in the process of the action research, Students worked in groups of two using a single computer. As shown by the experimental design detailed above, this research is based on the theory of constructivism and aims to achieve a conceptual change in students' alternative ideas through a cognitive conflict that should arise during the execution of the simulations.

4.3 Software "CROCODILE''

Simulations were performed by means of the simulation software "Crocodile Clips Elementary Edition". This is a free software which can be found in the website: http://www.crocodile-clips.com. It is characterized by the ease and simplicity of design and execution of virtual experiments concerning simple electric circuits and it is suitable for performing virtual experiments at all levels education. In the case of the current project it was used in primary education.
This software was chosen for the following reasons: i) students after following a brief demo of the program will be able to create their own experiments. More specifically, there are a lot of tools (such as light bulbs, battery, wires, switch, etc.) which students can easily select and drag-and-drop in order to place in the desired position, ii) the environment is user-friendly and iii) students have the opportunity to repeat the experiment, as many times as needed.
Two activities in the form of virtual experiments were performed using this software. The project had a dual focus, to teach with an interactive and innovative way both the basic concepts of electricity and simple electrical circuit, as well as the specific terminology related to the issue. .

Figure 1: The software of Crocodile clips elementary edition

5. Activities – Simulations

5.1 First Simulation

The purpose of the first simulation is to make students understand that both poles of the battery are needed for the bulb to light. :

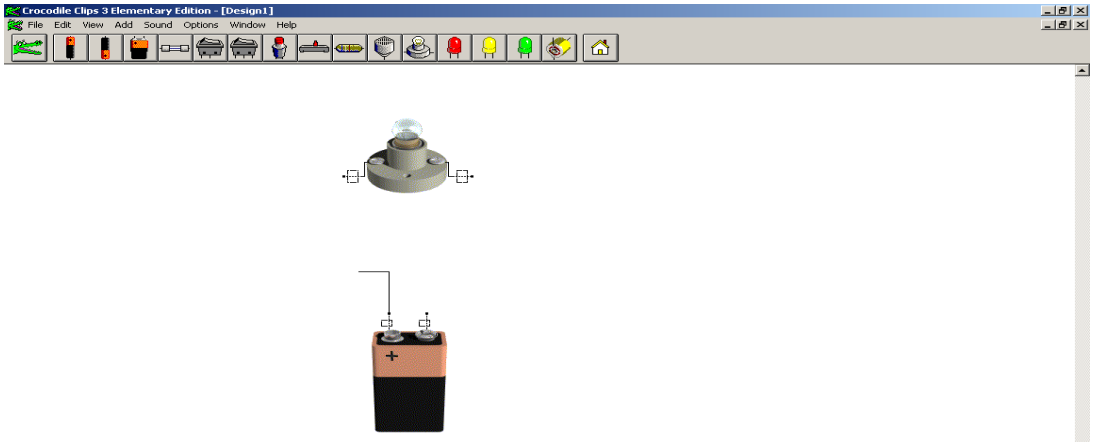

Figure 2: In the first simulation students were asked to light the bulb using the wires and battery

5.2 Second Simulation

The purpose of the second simulation is to clarify the notion of open or closed electric circuit so that students will not confuse it with the light bulb being switched on or off.:

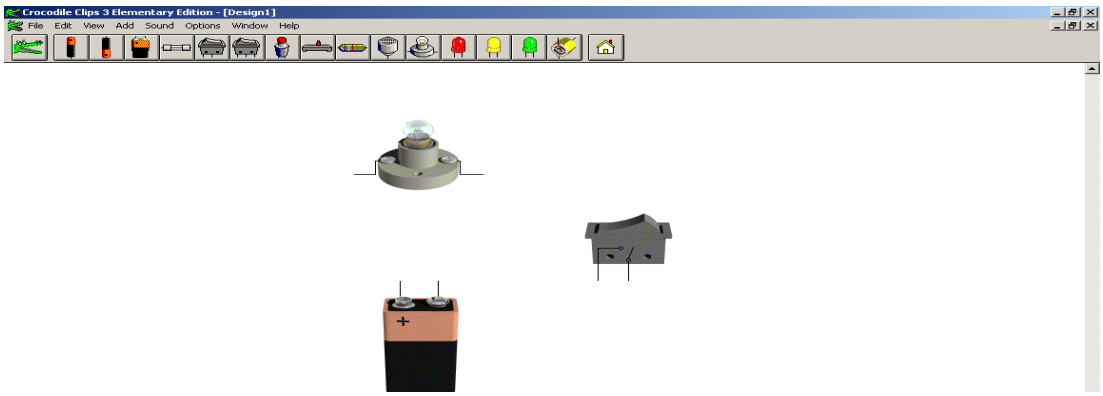

Figure 3: In the second simulation students were asked to indicate the role of the switch in the "open" or "closed" electric circuit.

6. Conclusions

The analysis of students responses showed that students fare better in the post-test, after the implementation of the intervention, than in the pre-test. The students of 5th and 6th grade of primary school that performed simulation have improved learning outcomes as follows:

The majority of the students changed the two basic alternative ideas that they had before the execution of experiments and through this conceptual change they acquired a sound scientific knowledge. Finally, after the activities and the performance of the simulations students seemed overall more comfortable to use the relevant scientific terminology for the concepts and the phenomena of electricity.

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