e-lab: a valuable tool for teaching

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Abstract. *In recent years the number of students choosing to pursue a scientific career has been decreasing, because they claim to be "difficult" to study these subjects. Having students motivated and interested in learning science is very important for the sake of the scientific culture and of our own future. Studies indicate that to reverse the previous situation, the teaching practices must invest in experimentation and new technologies. The essential goal of this study is to propose ways to achieve this goal. The e-lab is an excellent free resource that has both valences above mentioned, as evidenced by a preliminary study.*

Keywords. e-learning, Laboratory work, Teaching and learning science, Technology, Teaching / learning process.

1. Introduction

In the last years it has been observed a lack of motivation of students towards science subjects like Physics and Chemistry [1,2]. As such, to reverse this situation it is important to promote research that will help to change the mindset of the students in Physics and Chemistry, and Science in general, allowing them to acquire the desirable and necessary scientific literacy to understand the scientific phenomena that surround us. Several studies [1,3-6] indicate that the previous problem is related with the classic teaching approach and with the missing contextualization of scientific concepts.

As part of the solution to the students' lack of motivation and indifference for Physics and Chemistry we suggest a tool called "e-lab", which combines laboratory work and new technologies; valences that seem to be essential to increase students' motivation and interest in scientific subjects like Physics and Chemistry [1,3-6]. The e-lab is a platform to support teaching and learning of Physics and Chemistry that has been tested in the classroom and has proven to be an important tool in stimulating students to scientific subjects, holding their attention and increasing their motivation and interest in science contents. To confirm the encouraging results obtained so far in the teaching/learning of Physics and Chemistry with this platform, we intend to implement a national study in Portugal that will enable the utilization of the e-lab in any public or private school classroom.

2. Objectives

The e-lab platform primary goal is to help in the demystification of the failure causes of the teaching and learning of science, particularly Physics and Chemistry. Specific objectives are intended to: (i) allow students of various levels of education to be able to consolidate their expertise in science and hence develop their scientific skills; (ii) demonstrate that e-lab is a relevant resource for the teaching and learning of Physics and Chemistry; (iii) produce specific materials and scientific contents for students and teachers, as support of the platform; (iv) extend the existing range of experience, particularly in Chemistry; (v) reproduce e-lab experiments in several primary and secondary schools to decrease the time waiting to perform an experiment; (vi) contribute to the training of teachers; (vii) make e-lab an internationally recognized tool for teaching.

3. Description

Our work is focused in the development of an e-learning platform called e-lab. This platform is a real laboratory remotely controlled and thus has a great potential, as it may be used by students and teachers to collect real data from several experiments, anywhere and anytime, using a simple computer with an Internet

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connection, a player like VLC media player or QuickTime media player and Java Web Start. It is also possible to see the experiment at real time through a webcam, to use a chat room to talk with people connected to e-lab and to see the results of other people that are performing experiments when connected at the same time.

e-lab is a tool which aims to promote e-learning as a normal part of teaching along with time, complementing traditional teaching methods. It intends to support students in science learning, stimulating a scientific culture, and has no intention to replace the traditional lab. By the contrary! e-lab aims to be an ally for the traditional lab. e-lab also intends to allow experiments that for economic or security reasons are not possible to execute in schools.

e-lab motivational effect was already seen in a preliminary study [3] performed with students from primary and secondary education. With the help of e-lab we want to bring up the students' involvement and appreciation of investigation.

In the end of 2009 fifteen teachers of Physics and Chemistry from Portuguese primary and secondary schools in the Lisbon region performed a two months training using e-lab.

The training consisted in nine sessions of four hours each and was developed using the Moodle platform. Moodle is a software packaged for producing Internet-based courses and websites.

Three modules were developed with teachers in this training: (i) introduction of e-lab platform; (ii) tools for data analysis; and (iii) exploration of the e-lab in Physics and Chemistry teaching.

Teachers' continuous training is always important and necessary [7]. In the e-lab platform case it aims to help teachers with the e-lab interface and in the preparation and planning of experimental work.

The experiences currently available in e-lab are being embedded in a new interface (Fig. 1-2).

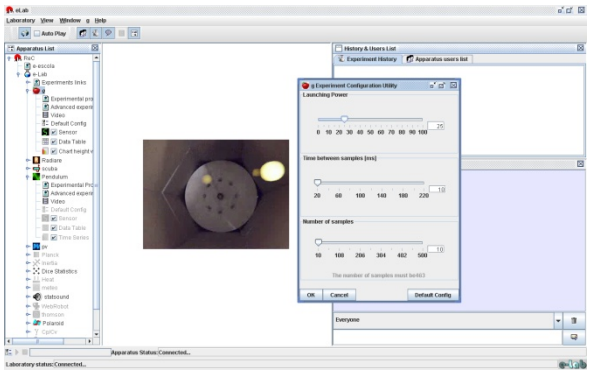

Figure 1. Old e-lab interface

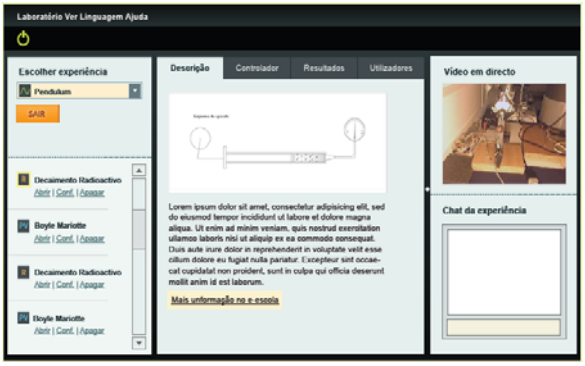

Figure 2. New e-lab interface

The new interface has many improvements compared to the previous. For example, it integrates the video (possibly due to the higher bandwidth available), allows data export to a spreadsheet, and is more intuitive and aesthetically appealing.

The platform has available more than ten experiments, mostly in Physics. For the continuous training four of these experiments were used, namely: (i) determination of earth gravity acceleration (Fig. 3); (ii) Boyle-Mariotte law (pressure change with volume) (Fig. 4); (iii) hydrostatic law (pressure change with depth) (Fig. 5); and (iv) launching data (statistic) (Fig. 6).

(i) Determination of earth gravity acceleration experiment

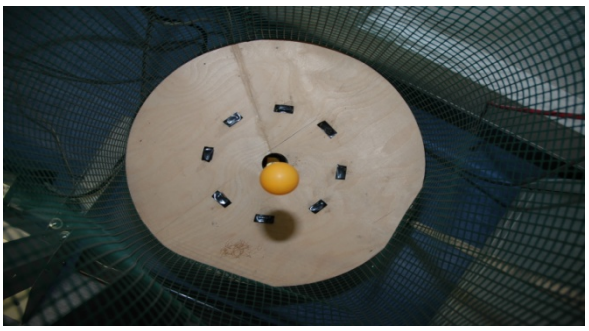

Figure 3. Apparatus for the determination of earth gravity acceleration experiment

The *g* parameter can be obtained by applying the gravity law on the serial results of the vertical temporal coordinate displacement of a ping-pong ball measured by an ultrasonic sensor.

(ii) Boyle-Mariotte law experiment

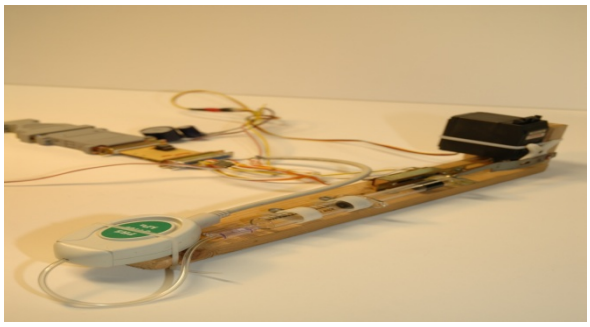

Figure 4. Apparatus of the Boyle-Mariotte law experiment

This laboratorial activity focuses the concept of "constant temperature"; in fact, the speed at which the experiment is conducted reveals that the law is always verified but it can only be considered an adiabatic expansion or compression if performed at a much higher speed.

(iii) Hydrostatic law experiment

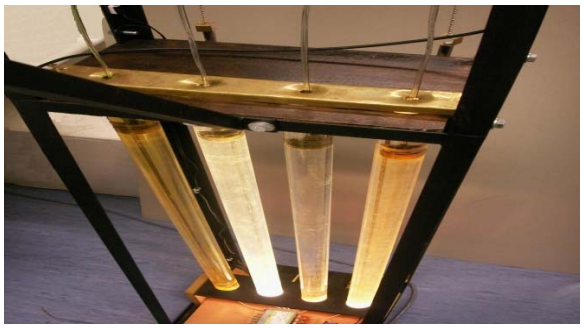

Figure 5. Apparatus of the hydrostatic law experiment

In this experiment you may find this principle for four different liquids: distilled and salt water, glycerine and vegetable oil. The density of each liquid can be calculated through the proportionality between pressure and depth. You will obtain data where depth causes a variation of the pressure given by $P = P_0 + \rho gh$, where P_0 is the pressure at the liquid surface, which is transmitted uniformly throughout the liquid (Pascal's principle) and ρ is its density (mass/volume). g is the acceleration of gravity and h the depth.

(iv) Launching data experiment

Figure 6. Apparatus of the launching data experiment

This experience is an automatic launch of a six-sided dice. To count the spots, proceed to the acquisition and automatic image analysis of these data. The values allow the study of the law of averages and the production of a statistical analysis of random phenomena. You can also use the images to develop proprietary algorithms and to the study various tools of computer vision.

3.1. Some results of the preliminary study

After e-lab continuous training (held with the old interface), teachers were invited to answer a few questions about the importance of the e-lab platform for the teaching/learning process. Only eight teachers answered it.

Some results of the inquiry are presented hereinafter.

Table 1. Answers: e-lab utilization

e-lab utilization	Classification 1-5
Relevance to teaching/learning	4.0
Simplicity to be used by students (user interface)	3.1
Simplicity to be used by teachers (user interface)	3.5
Simplicity to install the software interface e-lab, including QuickTime and Java Web Start	3.9

Table 2. Answers: e-lab in the classroom

e-lab in the classroom	Classification 1-5
e-lab experiences relevance to the curriculum of primary education	2.6
e-lab experiences relevance to the curriculum of secondary education	4.8
e-lab experiences feasibility in the classroom	4.0
Solution as a learning tool	3.9
Recommended utilization (upon e-lab availability to all schools)	4.4

Table 4. Answers: how much time did you spend, on average, in the execution of each e-lab experiment with your students (obtention of experimental data in the classroom)?

How much time did you spend, on average, in the execution of each e-lab experiment with your students (obtention of experimental data in the classroom)?	%
Less than 45 minutes	13
Between 45 minutes and 90 minutes	25
More than 90 minutes	62

Table 4. Answers: how much time did students spend in the data processing of each e-lab experiment?

How much time did students spend in the data processing of each e-lab experiment?	%
Less than 1 hour	25
Between 1 hour and 2 hours	25
Between 2 hours and 4 hours	37
More than 4 hours	13

Teachers revealed that the benefits arising from the use of e-lab by students are: (i) A laboratory practical activity that allows self-discovery as well as consolidation of knowledge; (ii) A lab always ready to use that allows the repetition of experiments, enabling more reliable results; (iii) The realization of experiences outside the classroom at anytime; (iv) The opportunity to carry out experiments without the existence of specific equipment in school; (v) The opportunity to use spreadsheets like Microsoft Excel; (vi) To use the Excel Solver tool to maximize solutions; (vii) The possibility to explore experiences that for financial or security reasons cannot be exploited in the school; and (viii) The statistical treatment of data obtained from a real experience (more at secondary level) and the analysis of graphs (where applicable).

The teachers referred to the difficulties they had when using the e-lab platform with students. They appointed: (i) The lack of school resources including computers with Internet connection, and the need to have Java and QuickTime installed in the computers to accomplish the experiments (this can be solved easily); (ii) Lack of time to adapt the experiences available to the school program contents; (iii) The e-lab training should begin before the school year planning in early September, and continue until the end of the third period. The exploitation of resources is fundamental; and (iv) Treatment of experimental results obtained through the remote control of experiments.

Points (ii) and (iii) should not be taken into account, since they relate to the time of completion of training.

4. Conclusion

Nowadays the influence of the Internet in our students is quite evident. In this context, it is essential to implement web contents and e-learning activities to stimulate the study and acquisition of knowledge by the students.

It is also important to use technology and laboratorial work to increase the interest and motivation of students towards scientific subjects such as Physics and Chemistry.

We must never forget that technologies and experimental work are only fantastic resources when well guided by teachers, that should stimulate students' interest in science, and we must never consider them as rescue strategy to motivate students [3].

From the results obtained in preliminary study we conclude that: (i) the enthusiastic results obtained in the preliminary study predicts a great future of e-lab; (ii) the use of technology and laboratorial work in the classroom promotes the students' interest and motivation; (iii) continuous training for constant updating of knowledge for teachers practices is needed; (iv) the e-lab is an intuitive platform that has the resources to explore the various experiences in classrooms at different educational levels; the

materials already prepared for the four experiments resulted in a preliminary study and were tested in classroom earlier (Fig. 7).

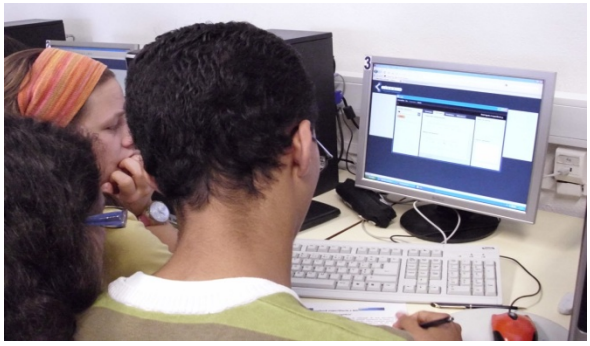

Figure 7. e-lab in the classroom

We believe that e-lab is a proper tool for experiments data collection using a simple, functional, user-friendly platform with all the necessary resources for students and teachers.

The e-lab project is a continuous process which aims to improve the materials that already exist and to create new support materials for teachers and students.

5. Acknowledgements

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