Inquiry Based Learning in Primary Education: A Case Study using Mobile Digital Science Lab

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This paper presents a case study in Primary Education that promotes children's inquiry thinking skills in Physics through the mobile digital laboratory '*Labdisc Enviro'*. The case study has been implemented in an authentic primary school environment and the underlying context of the scenario has been based on Physics 'Ecosystems' unit. Our main target was to investigate effective educational techniques along with the different ways they can be used in order to promote inquiry based learning in primary school children. The proposed teaching approach is based on the model of Inquiry Based Learning (IBL), which seems to be one of the most efficacious approaches for promoting the development of critical thinking, active learning and in-depth information processing by students (Hi et al., 2008; Minner et al., 2010). The use of the mobile digital laboratory '*Labdisc Enviro*' gave added value to our case study because '*Labdisc Enviro'* incorporates sensors that can replace traditional pieces of laboratories' equipment by converting a simple class into a digital science lab. In this way, students get engaged into hands-on lab activities, which make the learning process more effective, appealing and enjoyable (Globisens Net, 2012). Another target of our approach was to apply a combination of various modern techniques for ensuring an in depth (quantitatively and qualitatively) assessment of the students' performance. Finally, the paper includes the evaluation findings of a pilot study carried out so as to scrutinize the degree of acceptability, effectiveness and efficiency of this inquiry based learning approach.

Key words: Physics, Inquiry based learning, Labdisc, modern assessments techniques

INTRODUCTION

Research in the field of teaching science highlights as one of the underlying benefits of the laboratory the fact that it allows students to interact experimentally with materials and models, reinforcing the observation and comprehension of natural phenomena (Kind et al., 2011; Ding et al., 2011). In contemporary pedagogics / education, experiments are considered to be an integral part of the lesson as well as a dynamic tool which enriches and strengthens the learning process (Bond-Robinson, 2005).

Although experiential learning has proved more effective compared with teaching through virtual experiments, every today schools, are deprived of the equipment required to implement experiments . Equally significant with the technical infrastructure is the teaching approach that is chosen in order for the experiments to be put into practical use in everyday school life. In contemporary pedagogical theory and practice, Inquiry Based Learning has already been established as one of the most promising educational approaches as it promotes the development of critical thinking, active learning and an in-depth processing of information (Hu et al., 2008; Minner et al., 2010; Bolte et al., 2012).

Although in both Greek and international bibliography there has been a significant number of Inquiry Based Learning scenarios for teaching science in all levels of education, their main weakness lies in the fact that they do not include assessment methodologies and tools. For the teacher, assessing students' performance in Inquiry Based Learning scenarios is a particularly difficult and challenging venture, as they will have to take into consideration, record and evaluate a variety of parameters (Darling-Hammond & Adamson, 2010).

Responding to this challenge, this paper has a dual purpose: a) on the one hand, to thoroughly present the design, development and application stages of an authentic Inquiry Based Learning scenario that makes the best of the science data logger Labdisc, b) on the other hand, to facilitate the teacher to evaluate, as accurately and fully as possible, both the individual and team performance of students through the combination of contemporary assessment techniques.

In this paper the teaching scenario which was developed and applied as well as the students' performance assessment techniques are presented. The paper concludes with a summary of our future aims.

NEW TECHNOLOGIES AND LABDISC

Many researchers support that the use of new technologies in science education enhances students' performance (Cepni et al., 2006). However, there is a lack of a methodological approach and the main question still remains. For the educational community, instructional design using technology is a challenge and a teacher needs to be very careful in the creation of his/her teaching scenario that will incorporate new technologies in order to improve the underlying educational process. In many implementations of inquiry instruction, the use of data logging and sensors is an integral part of the student's engagement in inquiry learning.

The Labdisc is an interdisciplinary "digital lab" with application across the field of Natural Sciences. It incorporates sensors that can replace traditional pieces of equipment by converting each class into a science lab. This solves the problem of inadequately equipped school laboratories, while minimizing the time needed to prepare a science course. Finally, the compatibility with state-of-the-art technological tools that have infiltrated the schools, such as interactive whiteboards and tablets, enables students to further exploit the data of their measurements.

THE LEARNING SCENARIO

The meaning of ecosystem is familiar to primary school students and especially to those in the sixth grade. Students, however, are not familiar with the components it consists of. Furthermore student are likely to misunderstand the meaning and the difference between temperature and humidity and the different use they represent.

Educational Objectives

Students acquire knowledge regarding:

- recognize the main ecosystems,
- to find their differences,
- to discern the factors that constitute an ecosystem.

Students cultivate skills and abilities like:

- to verify experimentally if the temperature varies from one ecosystem to another,
- to determine differences in temperature and humidity at different times of the same ecosystem,
- to record temperature and humidity using ‘Labdiscs’,
- to verify experimentally the difference in temperature and humidity between
- ecosystems.

Students form attitudes about:

- to develop a positive attitude towards the use of scientific methodology
- export of valid results.

Inquiry Learning Method

The existence of students' primary ideas concerning the ecosystems has led us to the selection of an "evolving research teaching model " of Schmidkunz & Lindemann (1992) which has been adopted in the curricula of several primary schools (e.g. in Greece and Cyprus) (Sotiriou et al. 2010). The particular model includes four stages of teaching: (i) Introduction - Stimulus – Hypothesis Formulation, (ii) Experimental approach of the task, (iii) Inference, (iv) Consolidation – Generalisation.

The underlying teaching scenario consists of four distinct steps, the implementation of which was completed within 6 teaching hours. Below are the details of the development and implementation steps of the scenario, as well as the combination of assessment techniques (e.g. testing, evaluation rubrics, peer-assessment, portfolios, etc.) that were used by the teacher to assess both the individual and team performance of students.

1st Step. Introduction - Stimulus – Hypothesis Formulation

Introduction (Duration: 5 minutes)

Students start by watching introductory videos which show different types of ecosystems. Then, an initial discussion between the students and the teacher takes place in order for the latter to test their knowledge on ecosystems and remind them their names.

Hypotheses (Duration: 15 minutes)

After that, students work in groups of three or four formulating research hypotheses regarding: (i) the temperature that the school's ecosystem will have, the marine ecosystem and the mountainous ecosystem. Hypotheses are made at three different times - during the morning attendance of students, in the middle of the school day and during afternoon hours. Students have to record all their hypotheses on a worksheet which has been created and edited by the teacher.

2nd Step. Addressing the problem experimentally

Experimenting (Duration: 1 hour and 45 minutes)

Students conduct experiments in groups to test their hypotheses.

Experiment – students use Labdiscs to measure the temperature and humidity in selected ecosystems in the morning attendance.

After their arrival, students are divided in groups. Each group uses the Labdiscs to measure the temperature and humidity in the centre of the schoolyard taking rates concerning the school ecosystem. Then, they are taken to a nearby seashore where they also measure the temperature and humidity of the water. Due to technical difficulties, sea measurements are made at a very small depth. Finally, they are driven to the mountainous ecosystem where they make measurements of temperature and humidity respectively.

The same measurements are also made at noon which is considered the middle of the school day and at 2 in the afternoon before they leave school.

Measurements (Duration: 45 minutes)

In the next activity, the results of the measurements are discussed so that the changes in measurements in each ecosystem at different times during the day are put forth. For this reason, each group is given an evaluation sheet with a semi-structured conceptual map where students are asked to fill in keywords. The objective of this assessment is to enable students to match their measurements to those ecosystems, understanding their different characteristics.

3rd Step. Drawing conclusions

Conclusions (30 minutes)

Groups summarise their recordings through classroom discussion, reach their final conclusions and record them on the worksheet. These relate to: (i) the diversification of the temperature and humidity rates between ecosystems, (ii) the diversification at the different times of the measurements.

Feedback (Duration 15 minutes)

Then, the teams return to their initial hypotheses that were made at the first stage with the help of the teacher and they check - correct - fill in where needed. (Duration: 45 minutes)

4th Step. Consolidation - Generalisation

Everyday life connection (Duration: 10 minutes)

In this step, students are asked to connect their measurements to everyday life. Each group responds to short-answer questions (worksheet) plucked from everyday life concerning the variability of the temperature and humidity measurements.

Peer evaluation (Duration: 15 minutes)

Then, each group swaps worksheets with another group -which is randomly selected- and proceeds to the evaluation of responses, justifying only the wrong answers. After that, students go on to check peer-assessment through class discussion with the assistance of the teacher and its final finding is readjusted accordingly.

Rubric evaluation (Duration:10 minutes)

The assessment of the worksheet is achieved with the help of holistic rubric that evaluates the credibility and complement of answers. Students are provided with a clear guide for grading the worksheets depending on the importance of each criteria.

Then, the teacher discusses and specifies the right answers and the teams check their initial estimates. After the final correction, each team gives its final mark.

Evaluate individual performance (Duration: 10 minutes)

With the completion of the scenario, each student fills in, individually, a test with multiple choice questions, matching activities, right or wrong and short answers through which their individual performance is evaluated.

Additionally, the teacher assesses the portfolios with the teams' worksheets and gives them a mark. The worksheets are assessed according to: the accuracy of the measurements, the comprehensive overview of the worksheets, the inferences made, the argumentation-justification of answers.

Final Grading

Each student's final score results from the quota of each of the aforementioned performances (gradings). More specifically, it emerges from the following type:

Final Grade = + [Peer evaluation]

+ [Rubric evaluation]

+ [Individual test]

+ [final assessment portfolios]

CONCLUSIONS

In this paper, the design, development and pilot implementation of an authentic Inquiry Based Learning teaching scenario was presented that utilises the digital laboratory devices 'Labdisc Enviro' with 6th graders in their Physics course. The evaluation of the findings from the pilot implementation demonstrates that: (a) students responded very positively and with sheer enthusiasm towards utilizing Labdisc in their school, (b) utilising Labdisc in multiple Inquiry Based Learning activities greatly improved the process of restructuring the students' primary ideas and (c) the teacher, by implementing a combination of contemporary assessment techniques, evaluated with as much completeness as possible the students' individual and team performance. Our short term goal for the future is to design, develop and implement further teaching scenarios which will make the most of the added value of the digital laboratory Labdisc in all levels of schooling.

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