"PEC TASK EXPLORER": A TOOL FOR ICT SUPPORTED LEARNING IN SCIENCE

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ABSTRACT
In modern science teaching the role of ICT in supporting learning cannot be underestimated, let alone be ignored. Especially for the Predict-Observe-Explain strategy (POE), multimedia-supported POE tasks may be used as a diagnostic, pre-instructional assessment tool or a summative assessment tool. In recent years a handful of such tools have been developed, both through a generalised learning management system (such as LAMS) and as independent applications (Learning Designs). The tool we have developed is an advanced tool of the later type.

KEYWORDS
Software tool, Educational strategy, Predict-Observe-Explain (POE), Predict-Experiment-Compare (PEC)

INTRODUCTION

The use of ICT supported learning in Science is growing everyday worldwide. As the use of Information and Communication Technology (ICT) in teaching becomes widespread, science educators are faced with the challenge of making decisions on how best to integrate such technology within their teaching practice. Decisions on how to effectively integrate ICT to design pedagogically sound learning experiences can be quite demanding / overwhelming. The concept of a "university course" has broadened from a conventional model of synchronous teaching and learning activities (e.g., lectures and tutorials) to "unexplored dimensions" that include Internet based activities and the overall use of digital media to present, interact, and communicate in both synchronous and asynchronous modes (Botturi, 2006). Projects like the LiLa project (LiLa site, 2010) reflect this dimension. "LiLa" is the acronym for the "Library of Labs", an initiative of eight universities and three enterprises, for the mutual exchange of and access to virtual laboratories (simulations) and remote experiments (real laboratories which are remotely controlled via the internet).

The term "Learning Design" is gaining momentum in the e-learning literature as a concept for supporting academics to model and share teaching practice. According to Oliver and Herrington (2003) *Learning Design* refers to a sequence of coordinated online learning experiences, underpinned by a learning strategy, learning resources, and support mechanisms to provide guidance and feedback to learners. Since the definition and composition of learning design is still evolving, there is currently no standard mode of representation for learning designs in education, but, instead, there are several emerging learning design representations with different perspectives about their purpose (Agostinho, 2008).

Within this framework, in this work, we present the design and development of the tool "PEC Task Explorer", which enables the integration of Predict-Observe-Explain (POE) strategy for simulated and/or real experiment.

THE PREDICT – OBSERVE - EXPLAIN STRATEGY

The Predict-Observe-Explain (POE) educational strategy is widely used and reported in literature of science education for more than 25 years (White et al 1992). A POE task involves students predicting the result of a demonstration (or video) and then explaining any discrepancies between prediction and observation.

The in-lab variant of the POE strategy is called Predict-Experiment-Compare (PEC, Sassi et al 2008) is equally if not even more powerful strategy, especially for the physical sciences which typically involves: (i) a situation, asking for a prediction about what will happen *when a change is made*, and getting reasons for the prediction, (ii) performing the change and getting observations, and (iii) attempting to reconcile any conflict between prediction and observation.

The in-lab PEC strategy enables learners to understand, monitor and evaluate inquiry activities and learning process. In this case, strategies like POE or PEC, among others, provide students with a framework to guide their thinking which is important not only to improve their conceptual understanding and problem solving abilities but may potentially facilitate metacognitive skills.

Prediction elucidates students' ideas. The simulated experiments determine the level of abstraction in relevance of the scientific model and restrict the freedom of control, so as the students are focused on the manipulation of the parameters of the phenomena. The comparison of the results after the execution of the experiment with the ones in prediction phase may lead to the enhancement or the revision of the students' ideas.

Multimedia POE/PEC tools

In the first years of the application of this strategy, the procedure traditionally involved observable real time events as stimuli to provoke student thinking about concepts of science. More recently more teachers that use the POE strategy use computer-based POE tasks.

The advantages of computer-based POE tasks are significant. Computer environment allows students to engage in the POE task in small groups in contrast to the whole-class environment. The students are also allowed to proceed through the task at their own pace, thus giving them the opportunity to think, discuss and reflect on their predictions, observations and reasoning. Another significant advantage of computer-based POE tasks is that with the use of multimedia (video- sound- photographic demonstrations) the students are able to observe phenomena that could not otherwise be observed in a school lab and/or in real-time. An example Computer-based POE, has been recently developed by Kearney (Kearney 2003 and 2004).

In the PEC strategy, there are certain practical differences that need to be covered, in regards to the POE strategy. As stated before, the two pillars of this strategy are the experimentation and the comparison. Instead of presenting the students with a video of a phenomenon to observe, they are asked to perform an experiment themselves, which is either a real one in the school science lab or (most usually) a virtual one through the use of a computer simulation in the schools computer lab. Therefore, instead of having a passive observing role, the students assume an active participating role in the experiment/phenomenon.

With our tool, students are led to make that comparison, and are asked to rationalize and depict the scope of their ideas before and after the experiment. As an outcome the students embark in a short journey, a mini-quest of personal insight, that leads to better understanding of their misconceptions and ideas, not only by the teacher after the lesson but most importantly by themselves while they are still within the educational procedure.

DEVELOPMENT

Our tool, the PEC-Explorer Tool, was developed in principal based on the Learning Designs (A web-based multimedia library of multimedia-based POE tasks) by Matthew Kearney and it expanded on the principles of the PEC strategy. We wanted to make our tool more customizable and easier to use by a teacher with no knowledge of html or other advanced computer skills, furthermore we wanted to be able to expand it in the future with more features, and thus we chose Adobe Flash to develop it.

Description of the tool

In a typical PEC pattern students follow structured worksheets. An indicative structure is as following:

Table I. Indicative structure of the PEC strategy

Phase	Student Activities
Phase A	Students are initiated to the phenomena under study, often by engagement in a qualitative problem. The problem to be solved usually comes from everyday experiences, in order to be meaningful for the students.
Phase B	Students may make predictions about the evolution of the phenomena and the values of the quantities.
Phase C	In order to test their predictions, students set-up and/or run an experiment, observe the evolution of the phenomena and the real-time graph. At this point, students are often asked to change the values of the parameters, make new predictions on the basis of their findings, and run again the experiment.
Phase D	Students compare their predictions with the experimental results of previous phases take into account conceptual models, draw conclusions and discuss in the classroom.

Phases in the PEC strategy were analysed and transformed into 13 successive pages developed in Flash. Page description is outlined in Table II in accordance with the indicative structure of the PEC strategy (Table I)

Table II. Structure of the PEC-tool pages

Phase	Page	Page Description
Phase A	Page 1	Log in page
	Page 2	Introductory page
	Page 3	Question page
	Page 4	Description page
Phase B	Page 5	Prediction page
	Page 6	Reasoning page
	Page 7	Commitment page
Phase C	Page 8	Experiment page
	Page 9	Observation page
	Page 10	Explanation page
Phase D	Page 11	Compare prediction vs. observation
	Page 12	Compare reasoning vs. explanation
	Page 13	Report page

The first screen (Page 1) is the log-in page. Students are required to enter their team name/number and their individual names. Page 2 is the introduction to the task content. There is a short description of the activity and the environments to be used (i.e. simulated laboratory, real experiment etc.). Page 3 is the question page. The question comes from a real problem of everyday life. For example, for an activity where the surface is studied as a factor that affects heat transfer, the everyday experienced problem is:

"The milk that a mother had prepared for her baby was too hot. In order to make it cool down sooner she poured it into a larger pot, which had walls with same thickness. Do you agree with her action and why?"

Links prompt students for additional reading to answer the topic.

In the description page (page 4) a more analytic description of the task is presented and students are given an intro to the general steps they will follow. This page concludes the phase A of the structure of the PEC strategy

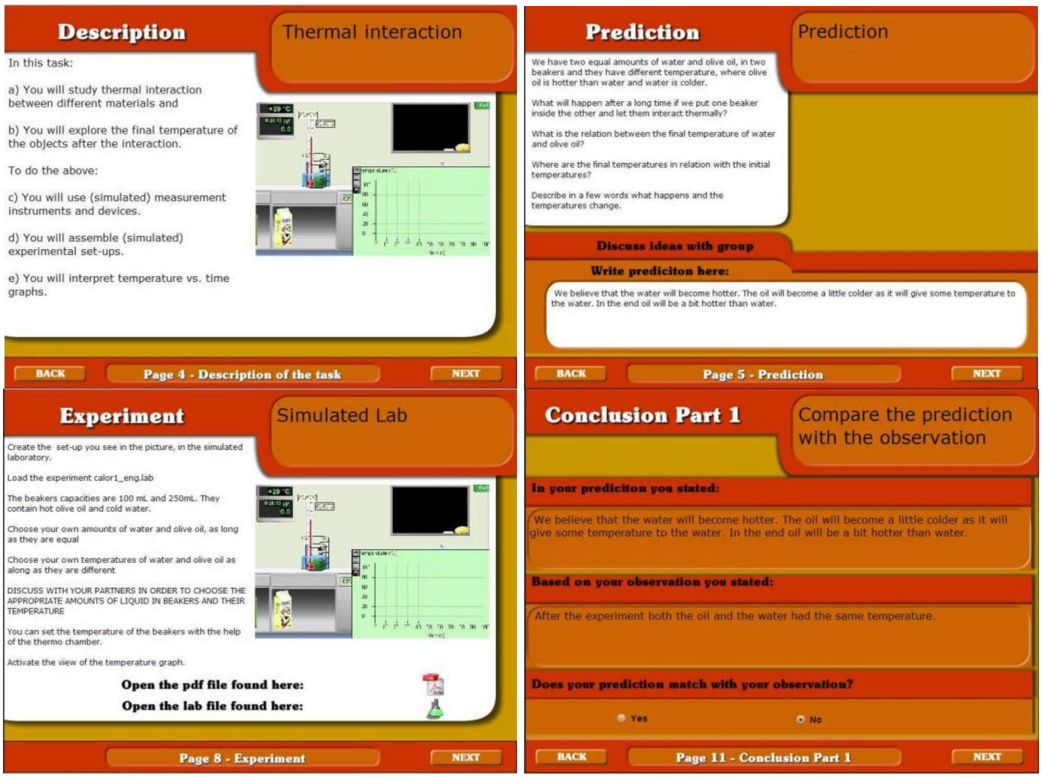

Figure 1. Characteristic screen shots for the PEC-Explorer Tool

Phase B, the "predict phase", starts with page 5. In this page, students are presented with the specifics of the experiment and the main questions of the task. In this phase the students are encouraged to discuss the ideas within the group and then type-in their prediction.

Page 6 is the important stage of commitment. Students are asked to individually state how committed they are to the prediction they made in the previous screen. The choices they are given are: "absolutely certain", "moderately certain" and "unsure". Students' commitment on what they think upon their prediction we believe is a strong point of the PEC strategy.

Page 7 is the reasoning stage. Here the students are once again encouraged to discuss and type-in the reasoning that led them to the prediction to the phenomenon. This page concludes the prediction phase (phase B) of the structure of the PEC strategy.

The experiment phase (phase C) contains two pages. In page 8 students are given general directions to the experiment itself and at this point two separate external files are supplied. One is the PDF file that the teacher has prepared with detailed instructions of the experiment and in case of the use of a simulated lab/environment, the lab file is made available. At this point there is no turning back to previous screens of the task explorer, so that one could not go back and change the prediction and reasoning after they made the experiment.

Students then move on to perform the experiment. In Page 9 and they are asked to type in their observation again after discussing it as a group. Page 10 is the explanation stage. Students are asked to discuss and write their explanation of the phenomenon based on their observation.

The final 3 pages (page 11-12-13) are devoted to the "compare phase" (phase D). Page 11 is the first page in the conclusion pages. Here the task explorer presents the students with their own prediction and observation from the previous stages. They are then asked whether their prediction matched the observation or not. In Page 12 the task explorer presents the students with the reasoning of their prediction and the explanation of their observation and are again asked if these two matched or not.

In the final screen, page 13, a report of the whole task is generated regarding the student's input and by hitting the "finish" button all the data collected in the previous stages with the task explorer are uploaded to the lab server. In the report, students, in one page, are confronted with what they had written in the prediction and their reasoning for that with what they have stated in the observation and their explanation.

The process in the compare phase (phase D, pages 11-12-13) is designed to trigger metacognitive activities. If there is no immediate connection between prediction and explanation, students usually accepted the results as de facto, not having to consider the differences and similarities between their prediction and explanation. The educational process ends for then, right then and there with a non-constructive acceptance of facts. Certainly in the cases where the teacher gathered the student predictions and explanation he/she could afterwards see clearly, understand and research on the student's misconceptions. But what if there were differences between their prediction and explanation? Comparison and pondering between the two, if not otherwise supervised by a dedicated teacher outside the available tools in use, was a matter of personal indulgence on the student's part.

Design principles

At first glance our tool looks and behaves more or les like other POE tools, (like "Learning Designs" by M. Kearney) by presenting the phenomenon to be studied using introduction pictures and text. The original POE tasks were based on templates (or 'eShells') designed by Kearney and Wright (2002) to support teachers' construction of their own photographic, sound or video (Kearney 2006). 'eShells', were a sequence of html based templates. The students' responses were implemented through cookie technology. Thus, though students could have access to what they have stated in their prediction, teacher had not. All students' answers were lost when Internet browser was turned off.

Our approach is different, and is outlined in Figure 2. The core for our "PEC explorer tool" is the Flash application. We adopted a client-server approach to ensure that instructor can have access to student's activity report. Texts and images and external files are not hard coded in the program but they are found in a simple XML file, which acts as a source. This enables any individual instructor without any programming knowledge to adapt and expand out PEC explorer tool, according to his/her needs. Flash application produces a "report file" on the student activity, which may be available to the instructor, as a XML file, through a php server.

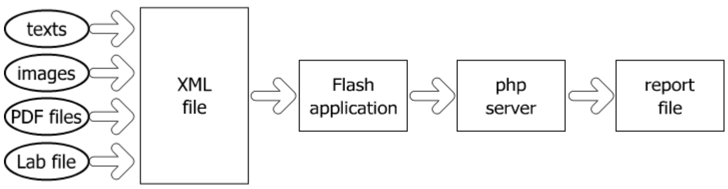

Figure 2. Schematic representation of the structure of PEC Explorer Tool

Easy customisation comes from the fact that all labels, text and graphics used (with the exception of the tool's "skin"), are taken from external XML files. XML files are simple, yet well-formatted tagged text files, which can be edited either by a simple text editor, or a specific XML editor. Several XLM editors are available for free in the Internet (ex. Microsoft XLM NotePad 2007), which go beyond the syntax highlighting offered by many plain text editors and generic source code editors, verifying the XML source based on an XML Schema, and some can do it as the document is being edited in real time.

The PEC-Explorer tool uses two XML files. One holds all the generic labels and text that task independent and is used to translate the tool to any standard language, and the other holds the specific to the task texts and references to graphics and other files. The later of these files (an example is presented in Fig. 3) is structured in "pages" which hold the title of each page in "ptitle" tag, the text in "ptext" tag, and the external files, like images ("pimage" tag), the required lab files ("plab" tag) and pdf ("ppdf" tag) links.


```xml
- <page7>
    <ptitle>Reasoning</ptitle>
  - <pdesc>
      Discus the reason that led your group to the previous prediction
    </pdesc>
  </page7>
- <page8>
    <ptitle>Simulated Lab</ptitle>
  - <ptext>
      Create the set-up you see in the picture, in the simulated laboratory. Load the experiment calor1_eng.lab The
      beakers capacities are 100 mL and 250mL. They contain hot olive oil and cold water. Choose your own amounts
      of water and olive oil, as long as they are equal Choose your own temperatures of water and olive oil as along as
      they are different DISCUSS WITH YOUR PARTNERS IN ORDER TO CHOOSE THE APPROPRIATE
      AMOUNTS OF LIQUID IN BEAKERS AND THEIR TEMPERATURE You can set the temperature of the
      beakers with the help of the thermo chamber. Activate the view of the temperature graph.
    </ptext>
    <pimage>Images/image1.jpg</pimage>
  </page8>
```


Figure 3. Sample of the of the task text XML file

The server-generated report file is also XLM structured. An example is given in Fig.4. As can be seen, the structure of the XML file gives to the teacher an outline of the whole PEC process. Teacher has access to the names of the students (team), their prediction, commitment, reasoning, observation and explanation and the comparison to what students have written in the prediction phase vs. observation and what stated in the reasoning phase vs. explanation.


```xml
- <Lab>
    <teamname>A1 Team 4</teamname>
    <name1>Giorgos</name1>
    <name2>Maria</name2>
    <name3>Nikoletta</name3>
    <prediction>We believe that the water will become hotter. The oil will become a little colder as it
      will give some temperature to the water. In the end oil will be a bit hotter than
      water.</prediction>
    <commitment1>Moderately Certain</commitment1>
    <commitment2>Moderately Certain</commitment2>
    <commitment3>Unsure</commitment3>
    <reasoning>It is because when two things with different temperature come together the hotter
      one gives some temperature to the other</reasoning>
    <observation>After the experiment both the oil and the water had the same
      temperature</observation>
    <explanation>the hotter substance gives some of its heat to the colder substance, and in the
      end they have the same temperature.It is almost what we predicted</explanation>
    <predictionagreement>No</predictionagreement>
    <reasoningagreement>Yes</reasoningagreement>
  </Lab>
```


Figure 4. Data collected

APPLICATION EXAMPLE

As an example of the use of our software we will present the application of "PEC Task Explorer" in use with a simulated environment (Thermolab) on the topic of Thermal interaction between different materials. Visually resembling a real-world laboratory, ThermoLab, consists of a working bench on which experiments can be performed with objects (beakers and heaters) to compose the experimental set-up, materials (solids or liquids) whose thermal properties are to investigate, and virtual instruments (thermometer, chronometer, heat-flow sensor) or displays including real time graphs. Students can use the objects with simple and direct manipulation: move the beakers, fill them with liquids, add solids or solvents, put one beaker into another, etc.

The subjects of our pilot study was a group of 3 students (13-14 years of age) of a typical class in a small secondary compulsory school, following an innovative teaching sequence with a strong laboratory character enriched with ThermoLab. The objective of the study was to test the applicability of the PEC-Tool developed.

Students in this example were faced with the following experiment setting:

- We have two equal amounts of water and olive oil, in two beakers and they have different temperature, where olive oil is hotter than water and water is colder.
- What will happen after a long time if we put one beaker inside the other and let them interact thermally
- What is the relation between the final temperature of water and olive oil?
- Where are the final temperatures in relation with the initial temperatures?
- Describe in a few words what happens and the temperatures change.

The tool developed was found successful in running and collecting data, and was found easy to use by the students. After the completion of the process the data were gathered with our tool in the school lab server. As can be seen in Fig. 4, for their predictions, our group of students have stated: "*We believe that the water will become hotter. The oil will become a little colder as it will give some temperature to the water. In the end oil will be a bit hotter than water*". In their reasoning, they have stated: "*It is because when two things with different temperature come together the hotter one gives some temperature to the other*", and in their explanation: "*the hotter substance gives some of its heat to the colder substance, and in the end they have the same temperature. It is almost what we predicted*".

The above data is an example of student's misconceptions about discriminating the use of terms "heat" and "temperature" as they unfold with the use of our tool. Students stated in their reasoning: "*… when two things* (meaning substances) *come together, the hotter will give some <u>temperature</u> to the colder*". After the experiment, in their explanation students corrected their view as "*… the hotter substance will give some of its <u>heat</u> to the colder… and they will have the same temperature*" What is specifically interesting is that it is prominent to the teacher in the end of the data (i.e. the end of the process) that the students still believe they were correct even though the observation was just "*almost what we* (they) *predicted*". Collecting such data on what students believe on their ideas is a strong point of the PEC strategy.

CONCLUSION

In this work, we present the design and development of a tool ("PEC Task Explorer"), which enables the integration of Predict-Experiment-Compare (PEC) steps. Our software was developed with Adobe Flash. The PEC strategy is a variation of the POE; the difference lies in the fact that the students are presented with a phenomenon, asked to make a prediction and to give the reasoning for that prediction. Then the students are presented with the experiment they must undertake and afterwards asked to explain and rationalize the phenomenon as it was experienced. As a last step the students are asked to compare their prediction before and their explanation after the experiment.

The tool was developed in such a way that the students' actions and results are automatically logged through a lab server or web server and therefore made easily available to the teacher after class. Since we wanted to give the teachers an easy way to create their own PEC tasks, we took special care so that our tool would be open on the teacher's end. In that sense, any teacher with basic computer skills can create his/her own tasks by editing the simple xml files accompanying our tool that are the source of the texts and the other elements that comprise each PEC task. The novelty of the tool designed is two-fold. On one hand, it lies in the analysis of a typical PEC strategy, and its transformation into thirteen successive pages. On the other hand, it lies on the fact that it uses XLM files as to provide users (teachers) with an easy way to access view and edit information.

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