TALKING PHYSICS IN INQUIRY BASED VIRTUAL LABORATORY ACTIVITIES

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Introduction

Labwork in Science Education

- During the last few decades, there is an on going conversation about the labwork in Science Education
- Although science educators, researchers & curriculum developers mostly agree on the importance of labwork
- Criticism has also been expressed about the learning taking place during labwork
- Suggestions about further research in what actually students are doing and/or learning

  - (Hofstein and Lunetta, 1982; 2004; Tobin 1990; Hodson, 1993; Lazarowitz and Tamir, 1994; Hofstein, 2004; Lunetta et al., 2007; Hodson, 1990; Leach & Paulsen, 1999)

Labwork objectives

- Three major objectives can be defined:
- A. The students' linking between theory & practice
- B. The students' developing experimental skills
- C. The students' getting to know the methods of scientific thinking
    - (Welzel et al., 1998; Millar et al., 2002)

Mismatch in Labwork's objectives

- It is considered that during labwork, declarative & procedural knowledge are interconnected and students should use them simultaneously in order to be engaged in effective labwork activities (Sere, 1999)
- There seems to be a mismatch between the intended aims of the educators & curriculum developers and the actual activities of students (Lunetta, 1998)
- On this bases, Psillos & Niederrer (2002) suggested that there should be an investigation about the **effectiveness of labwork** by examining how students intervene in the "world of laboratory" and how students administer the entities of this world
- The world of laboratory comprises of specially constructed or common life objects & equipment, physical or virtual

Effectiveness 1 & 2

- They suggested evaluating the quality of a given laboratory activity by linking it to a specific type of effectiveness called **effectiveness-1**
- Effectiveness-1 can reveal the complex interplay between theoretical representations & practical activities and the linking between them, **during the activity**
- On the other hand **effectiveness-2** refers to the evaluation of students' learning in relation to the learning objectives
- Effectiveness-2 is widely & traditionally used for investigating students' achievement **after** the completion of a piece of labwork
- Both effectiveness-1 & -2, can be used for the evaluation of the three **labwork objectives** mentioned earlier

Aim of our study

- Adopting the model proposed by Psillos & Niederrer (2002), we aim at evaluating the **objective A**: "students' linking between theory and practice", in respect to **effectiveness 1.**
- In detail, we are investigating whether students create links between theory and practice during labwork, and further more if this is related to the kind of activity they are engaged in, while working in a simulated laboratory environment called **'Thermolab'**
  - (Hatzikraniotis et al., 2001; Zacharia et al., 2008).

CBAV method: evaluating effectiveness-1

- Category Based Analysis of Videotapes **(CBAV)** method
- Proposed by Niederrer et al. (1998)
- Used for effectiveness-1 (Buty, 2002; Hucke & Fischer, 2002; Sander et al., 2002; Theyßen et al., 2002 ; Kirstein & Nordmeier, 2007)
- Also for other in depth studies (Enghag, 2007; Scharfenberg, 2008)
- According to this method, they analyze **how often** and in **witch context** students **talk about physics** during labwork
- Effectiveness-1 can be evaluated by relating the amount (Density) of **students' verbalization** of knowledge, to specific **labwork context** (taking measurements, interacting with tutor)

Knowledge verbalization density

$$Density(KP/X) = 100 \cdot \frac{\sum Timeunits\_KP\_in\_X}{\sum all\_Timeunits\_X}$$

- X is the laboratory context
- KP is a verbalisations catecory
- Categories related to labwork context are more or less obvious, depending on the sources available to the students.
- Timeunit should not be mistaken for seconds or minutes

A challenge

- Typically, the manipulation of apparatus and measurements in a **traditional laboratory** took most of the time (about 50-80%) of labwork, while these lab contexts result to a **low Density** verbalization of Physics (lower than 10%).
- How can this change in a simulation based setting, given the shorter time to run experiments?

Research methodology

Research question

- **'How does the engagement of the students in different types of laboratory activities with manipulations of virtual objects and devices in 'Thermolab', affect the density of Physics Knowledge verbalisation?'**
- Du et al. (2005) in their scheme, have classified in-class experiments from 'demonstration and cookbook lab' to 'studentdirected and student-designed inquiry', identifying 6 levels: lecture/demo, cookbook lab, **structured lab**, challenge lab, **student-directed inquiry** and student-designed inquiry.
- In this work we are concerned about two types of activities
- One type of activity called **'close type'** refers to the **structured lab,** where the experiment is pre-set.
- One other type of activity, called **'open type'**, refers to a **student directed inquiry** type situation. In this case, students are offered an open space for intervention, and are allowed to do any possible manipulation (within the boundaries of the virtual world).

Thermolab

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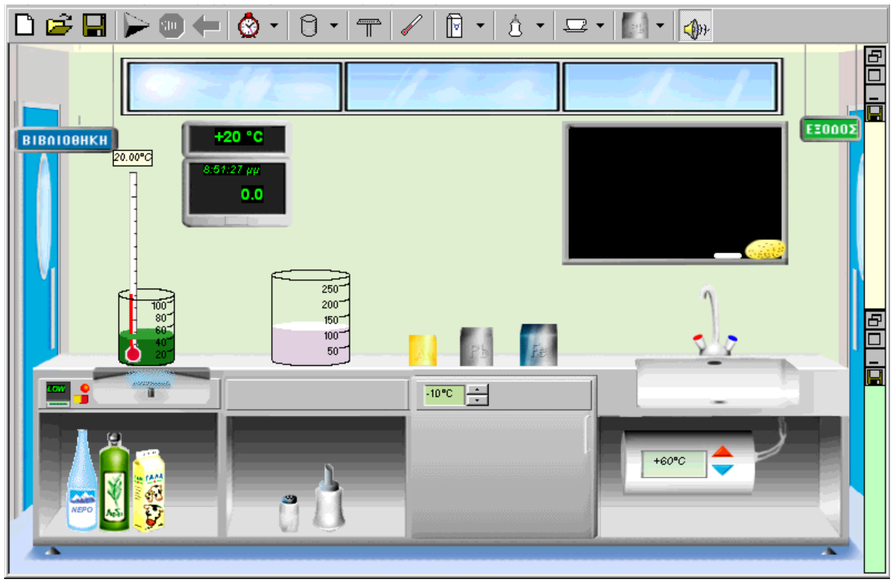
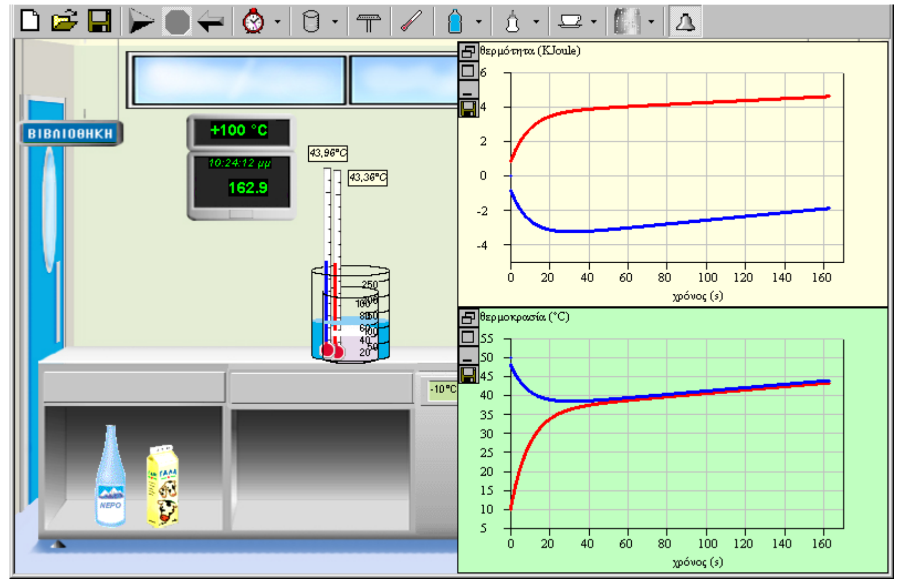




Context

- The subjects were 14 Greek secondary school students (13-14 years)
- Students worked in (7) pairs, each pair having their own computer and worksheets
- Innovative teaching sequence with a strong laboratory character enriched with ICT
- Covering topics concerning Thermal Phenomena included in the curriculum
- Students' conversation was recorded in video and also in audiotapes
- Conversations were coded and analyzed using the CBAV method

Activities

Activity	Topic	Type
Rad.1	Thermal radiation – bodies of different color	Closed
Rad.2	Thermal radiation – bodies of different surface area	Open

- These activities were selected as representatives of the **'close'** and **'open'** type, described earlier, in order to provide testing ground for our research question.
- Both activities refer to Thermal Radiation and this way they also share the same conceptual content, as presented in the next slide

Activities

- **Rad.1:** Pre-set. A **black** and a **white** painted beaker containing the same amount of water of the same high initial temperature are placed in a colder surrounding temperature.
- The objective is to measure the **time** necessary for each beaker to reach the final temperature, thus concluding on the effect of **color** to the emition of thermal radiation
- **Rad.2:** students are investigating the relation between the total **surface** of a body and the rate of thermal radiation emitted.
- Students using the objects, apparatus and initial values of their choice, are setting up an experiment relevant to this problem question.
- The objective is to measure the **time** necessary for bodies of different total surface, to reach the final temperature, thus concluding on the effect of **surface** to the emition of thermal radiation.

CBAV category coding & description for laboratory context

Category / sub		Code	Description	Example
Simulation	Set-up	SIM	Use the simulation to set-up the experiment	Students manipulate virtual objects and devices, to set the appropriate initial temperatures of water and oil
	Measu-rement		Use the simulation to take measurements	Students are following the progress of an experiment from the thermometers and the real-time graph, reflecting on their initial predictions
	Results		Use the Worksheets to record the results	Students are recording the data from the screen to a table in the Worksheet

CBAV categories coding & description for verbalisation

Category	Code	Description	Example
Virtual objects	**VO**	Verbalization about manipulations of virtual objects and devices	Students talking about the way to empty a beaker and to refill it again
Virtual objects & Physics	**VP**	Verbalization about physics concepts concerning virtual objects	Students talking about the temperature of water in a beaker
Physics Theory	**PT**	Verbalization about Physics theory or students perceptions	Students predicting the final temperature that a beaker will reach

Basic choices in CBAV

- Time interval for the data collection = 30 secs
- ‘Wait time’ of the faster groups, was not accounted for the calculation of the Density
- The contributions from each member of the pair were coded, and the mean value was then used for the calculation of the Density
- Data were coded in more than one verbalisation categories, even if they appeared in the same time interval
- A sum of Density of verbalization in categories considered as related (in our case PT and VP) can be calculated
- A broader list of categories of knowledge verbalisation and labwork contexts were coded, but are not presented here. This work only refers to the categories related to students’ working with the virtual laboratory ‘Thermolab’

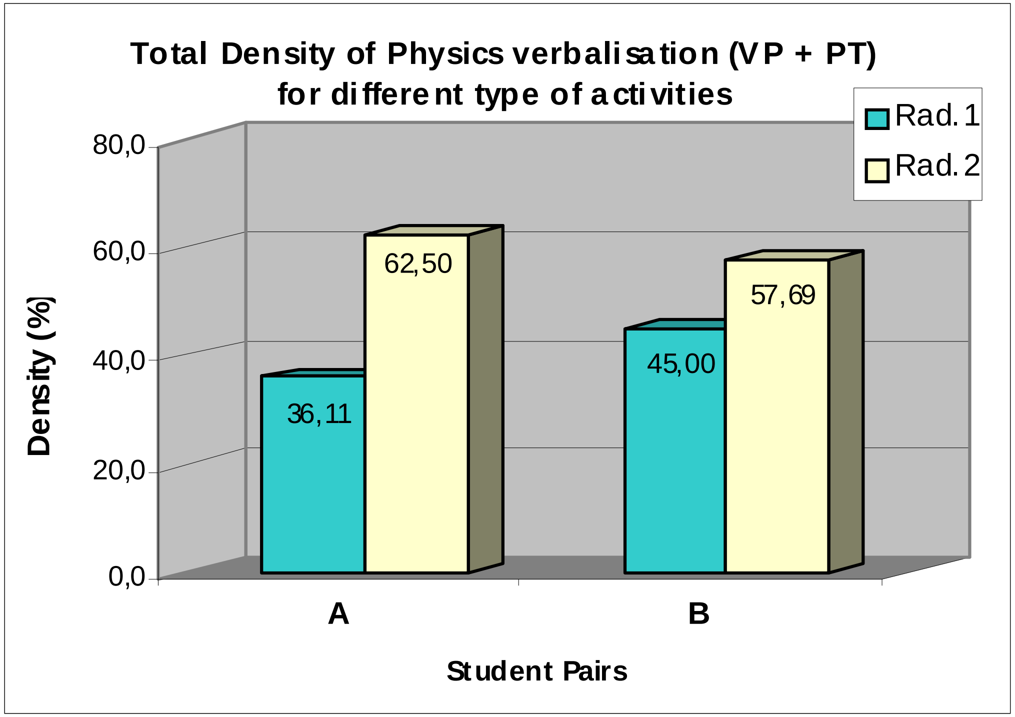
Results

Results are presented in 3 aspects

- A) A cross-comparison of the total density of physics verbalisation (VP+PT) for the activities of two student pairs working with “Thermolab”
- B) A detailed comparison of the density of the components of physics verbalisation (VP & PT) for each one of the activities
- C) A detailed comparison of the density of verbalisation about virtual object manipulation (VO) against the total density of the components of physics verbalisation (VP + PT) for each one of the activities

A) A cross-comparison for total density of Physics verbalisation (VP+PT)

close type activity



open type activity

The total Density of physics verbalisation (VP+PT) in the **'open type'** activity is greater than in the **'close type'** for both student pairs.

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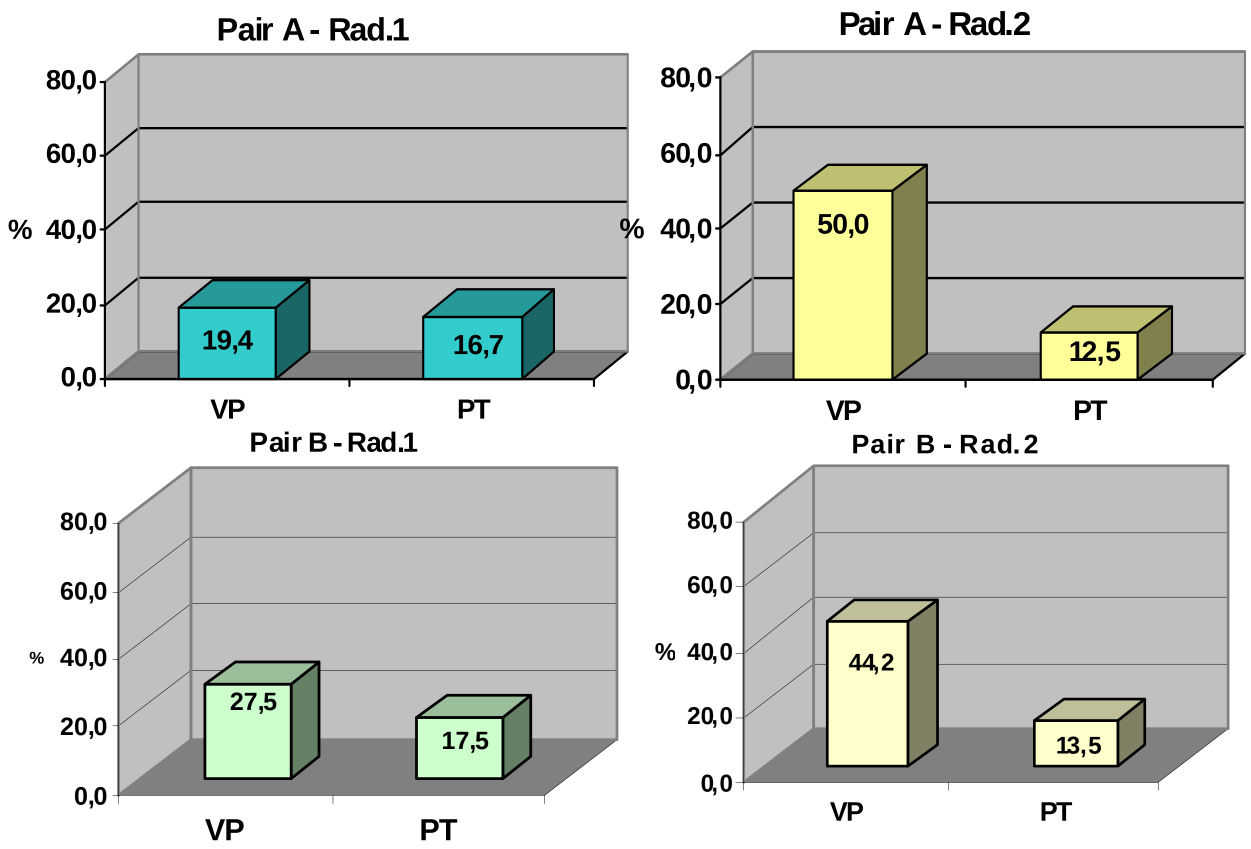
B) A detailed comparison of the 2 Physics components (VP and PT)

close type activity



open type activity

The Density of Physics Theory ranges in the area of 10-20%.

The Density of verbalisation about the physical properties of the objects (VP) is bigger for the **'open type'** activity & smaller in the case of the **'close type'** activity.

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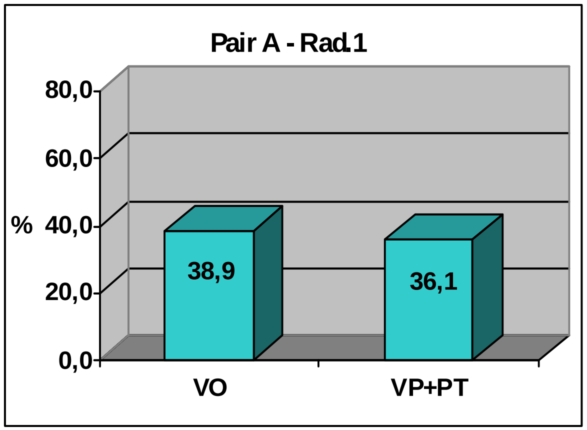
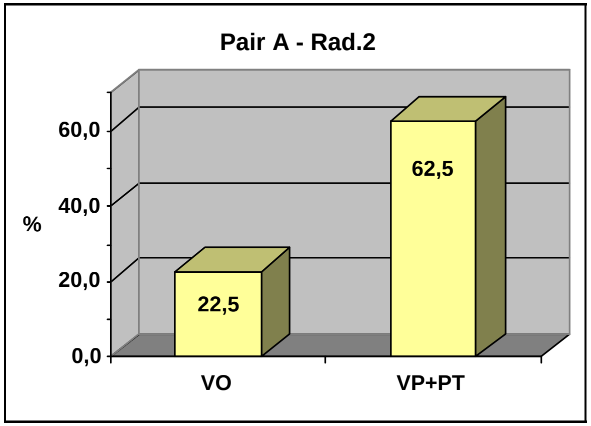
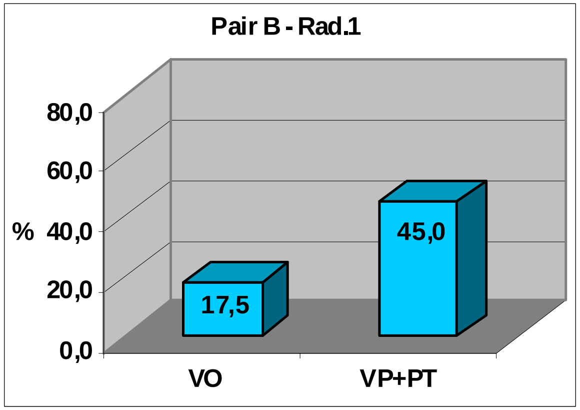
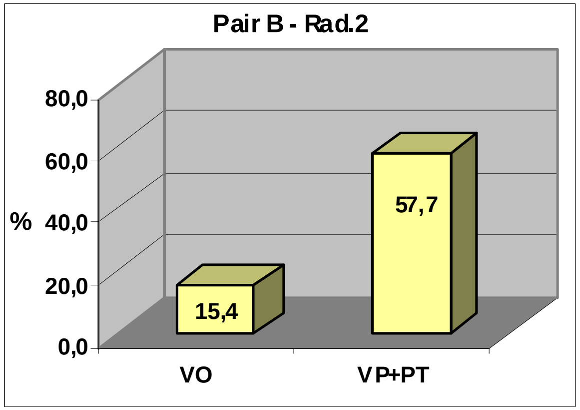
C) A detailed comparison of (VO) against (VP + PT)

close type activity









open type activity

For the **'open type'** activity the total Density of Physics (VP+PT) is about three times larger than the Density concerning virtual object (VO).

For the **'close type'** activity the total Density of Physics (VP+PT) is lower and the Density concerning virtual objects (VO) is greater (of the same pair).

Discussion

- Observing on the **difference** in the total Density of Physics knowledge verbalization (VP+PT) between the **'close type'** activity and the **'open type'**,
- We suggest that
- **The engagement of students in inquiry type laboratory activities results in a greater density of Physics knowledge verbalisation**.
- Based on the theoretical background of the **CBAV** method, this means that **students are creating more links between theory and practice**, during an inquiry type labwork activity.

Comment -1

- The Density of verbalisation about Physics concerning virtual objects (VP),
- is very high in the case of the open type activity
- and rather low in the case of the close type
- this is the main reason for the effect on the total Physics knowledge verbalisation (VP+PT) discussed earlier.

Comment -2

- In all the activities (open & close), a relatively similar Density of verbalisation concerning physics theory (PT) was observed
- This provides evidence about students' creating links to Physics theory,
- Meaning that a level **of abstract thinking** is also fostered while working in a virtual environment like 'Thermolab'.

Comment -3

- The Density of verbalisation about virtual objects manipulation (VO) is **higher during the close** type activities, than the ones during the open type,
- This appears to be **contradictory**
- But Density is a **relative** and not an absolute quantity,
- if an activity lasts for a **shorter time** (as expected for a structured lab), the same amount of verbalisation results to a **higher Density**.

Conclusions

- When students are engaged in virtual laboratory activities using ‘Thermolab’, in different types of activities there seems to be **linking between the world of theory and the world of objects & events**
- This linking is much more apparent in the case of **inquiry based activities**, rather than the case of structured lab activities.

The end

- Thank you very much

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