ACTIVE LEARNING IN PHYSICAL LABORATORY

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Abstract

In the contribution there is an importance of active learning presented, i.e. learning where students become active participants of the learning process. Active and collaborative learning can be realised in the physical laboratory. There are two possible methods of active learning in the physical laboratory presented: microcomputer-based laboratory and black-box method.

KEYWORDS: active learning, microcomputer-based laboratory, black box

Introduction

Research in education in different countries show that students at secondary and even university level continue to hold fundamental misunderstanding of the world around them [1,2]. Science learning remains within the classroom context and just a small percentage of students is able to use the knowledge gained at school for solving various problems of larger physical world.

In most of the courses students „do“ no science. They hear lectures without strong connections to their everyday experiences. Students usually do not have opportunity to form their own ideas, they rarely get a chance to work in a way to be engaged in discovery and building and testing models to explain the world around them, like the scientists do.

Active learning

Results from research in cognitive science and education show the importance of empirical and phenomenological experiences in learning science. One of the ways how to do it is to provide the means for students to form concepts from their own concrete experience. This is known as an **active learning** that means that students take an active role in the process of learning [1,2,5]. Students should not be just passive listeners of lectures; they should become active participants of the learning process. They should „do“ science the similar way the scientists work. They should form their own questions, create hypothesis, own theories, make assessments and predictions about the future of the physical process, they should prepare experiments, collect and process physical data, manipulate, discuss and think about them, and last but not least, they should communicate and collaborate with their peers.

One of the places where **active and collaborative learning** can be realised is physical laboratory. We present two possible methods of active work in the physical laboratory.

1. **Microcomputer-based laboratory** that gives the student power to explore, measure and learn from the physical world with a help of the computer used as a measuring tool.
2. **A black box method** is the method of learning, in which students find the structure of the black box by investigating its behaviour through experiments.

Microcomputer-based laboratory (MBL)

The examples given are concerning the laboratory exercises using MBL accompanied by temperature probe that can help students in understanding the concepts of temperature and heat energy. Before they start measuring, they have to calibrate the temperature probe. Such a calibrated temperature probe can be used in every experiment where the temperature is measured and the result of measurement is a graph of temperature versus time that represents the temperature history of a substance.

Examples of laboratory activities that take advantage of this capability include: cooling and heating of liquids, the influence of the mass of a substance on cooling or heating rates, the influences of the heat added and the different substances on cooling or heating rates, changes of state, effects of pressure on the boiling point of water, etc. They can be realized as lecture demonstrations or students laboratory exercises in undergraduate students preparation. In the next paragraphs we describe the temperature probe calibration and an example of laboratory exercise aimed to determination of the specific latent heat of vaporization of water.

Temperature probe and its calibration

The temperature probe is connected to the interface card via measurement console (fig.1). The probe linearly transforms temperature into voltage. It has a range of -18 to 110°C (0-2,5 V).

First of all students have to set up their apparatus and probes, set scaling and calibrate the probes. Since the temperature probe is linear, they calibrate it by reading two values of temperature and corresponding voltage, usually by taking the boiling and the freezing point of water. The calibrating curve is then saved on the disk.

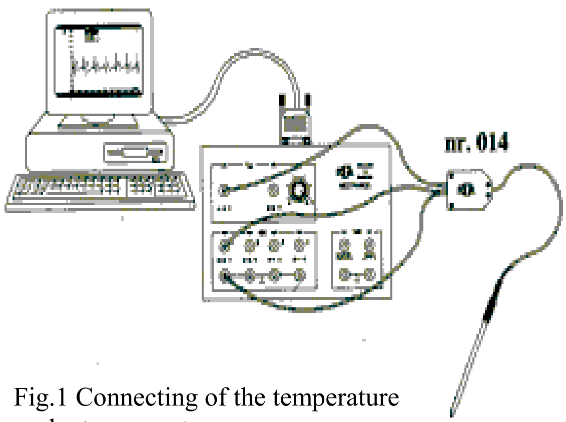

Fig.1 Connecting of the temperature probe to computer

Determination of specific latent heat of vaporization of water

Physical principle:

The specific latent heat of vaporization of a substance is the amount of heat that must be supplied to change 1 kg of the substance at its boiling point from the liquid to the gaseous state. The same amount of heat must be removed from 1 kg of the substance in the gaseous state at its boiling point to change it into a liquid.

Materials:

Bunsen burner, adjustable clamp, ring stand with asbestos gauze, container for making steam (steam generator), boiling chips, water trap, thin rubber hose**,** insulated cup or thermoflask, two temperature probes, microcomputer with interface card and measurement console, IP COACH software

Procedure:

Assemble the apparatus as shown in fig.2. Find the mass of the thermoflask. Fill it two-third full with cold water and find its mass. Find the mass of cold water.

Use two temperature probes, insert one into the steam generator and the other one into the thermoflask. Heat the steam generator until the steam is coming from the trap. Start recording the temperature of water in the thermoflask with a help of MBL tools. Stir the water and when its temperature is about 15°C higher than the initial temperature, quickly remove the trap.

Continue stirring and stop the measurement. Save the results on the disk. Find now the mass of the thermoflask and its contents. Find the mass of the steam added to the water.

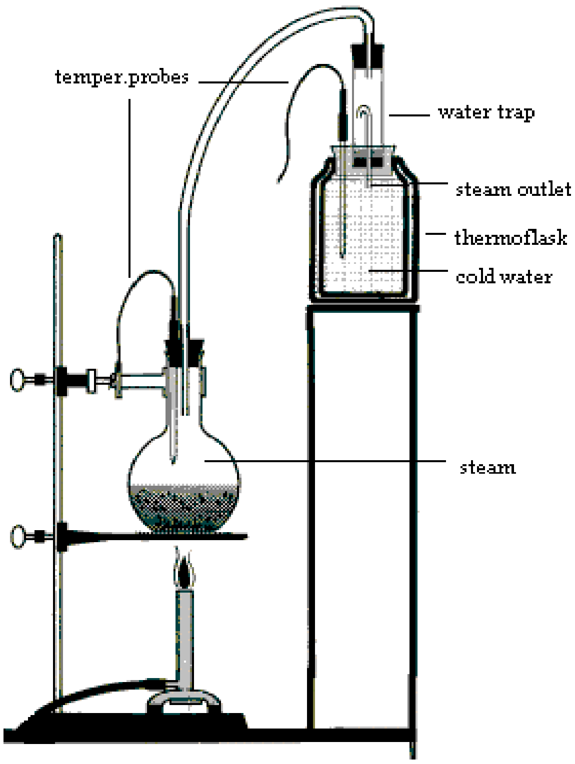

Fig.2: Apparatus for studying specific latent heat of vaporization of water

Processing:

From the temperature versus time graph (fig.3) find the initial and the final temperature of water in the thermoflask. Calculate the quantity of heat given out when 1 kg of steam condenses, i.e., the specific latent heat of vaporization l_v using the Principle of heat exchange that says

$$L + Q_1 = Q_2 + Q_k\,, \qquad (1)$$

where the symbols means:

$L=m_v.l_v$ - amount of heat lost by steam in condensing (m_v-mass of the condensed steam),

$Q_1=m_v c\Delta t'$ - amount of heat lost by condensed steam in cooling,

$Q_2=mc\Delta t$ - amount of heat gained by cold water in warming (m-mass of water),

Q_k – amount of heat gained by the thermoflask.

Solving equation (1) find the specific latent heat of vaporization of water (l_v) and compare it with the expected value.

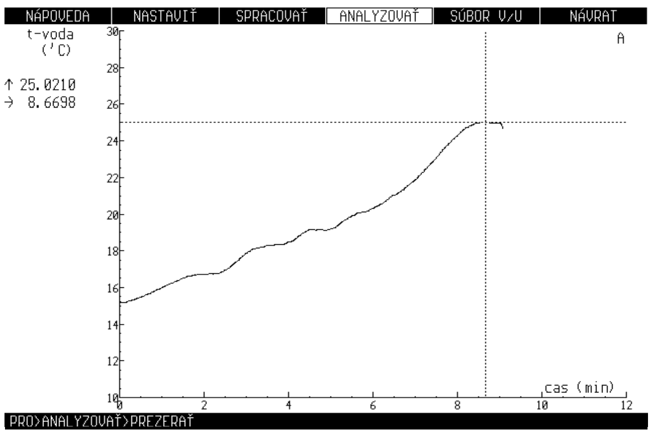

Fig.3: Temperature versus time graph for 545 g of water in which 13,8 g of steam condensed

The black box method

The method of black box requires operational joining of thinking operations of analysis and synthesis with a specific experimental activity and so it represents one of research approaches to the solving of physical problems.

From the didactic point of view, the black box may be considered as a problem solving, which consists of the indirect revelation of the internal structure of the box. Black box is thus any relatively closed system whose structure is not known at all, or only partially and is inaccessible to such an extent that it cannot be determined by direct observation. We can make conclusions about the structure of the black box on the basis of its behavior, which is investigated through experiments.

Black box in teaching physics

Since the method of solving the problem of black box belongs to the most important methods of obtaining knowledge on real life, it is necessary that students get acquainted at least with the simple version of this method during the physics courses.

In physics teaching the method of black box may be applied in a number of ways, which differ from each other by the topic, complexity of the problem, the method of realization and the system of work. Chosen method depends on teaching goals, nature of the taught topic and the level of intellectual capabilities of students.

In physics teaching at universities the method of black box may be used:

- to deepen the knowledge in the stage of strengthening the knowledge, for example during laboratory work
- in final control in the stage of checking the knowledge of students (as a part of written or oral exams)

It is possible to work with real or model black boxes.

Critical point in giving the task to the students is the scope of information about the possible structure of the box. Successful solving depends on the selection of necessary knowledge and some instruction on how to proceed, which should be given to students. Less instructions provoke more creative thinking. Exceeding of the acceptable scope of information may, however, lead to the loss of interest and possibly also to the blockade of creative thinking originating from the feeling of inability to solve the problem of black box.

Experiments with black boxes

That the method of black box is not known very much and even used less at schools. Students of physics get very little acquainted with this method without any possibility to use it practically. This is why we have adopted a more open-ended approach to electrical laboratory investigation. We present our students with a set of electrical black boxes. The object of exercises is to determine something about the contents of the boxes without looking inside. Black box is used as a mean for checking the knowledge within a group form of teaching.

Our black boxes contain individual electronic elements (resistor, coil, capacitor etc.), connected into simple circuits. Students were given black boxes as problem tasks. The goal was to determine individual elements contained in the box. Students could use leads, ampere-meter, voltmeter and source of d.c. and a.c. voltages. They were also informed about all possible internal connections.

In the first test every group of 3-4 students received five black boxes containing individual electronic elements (resistor, coil, capacitor, diode, insulator), which had to be determined within 30 minutes. During this time all groups have measured all boxes and the average rate of success in determining the elements was 80%. Students made mistakes in distinguishing coil and resistor. During the evaluation each group reported the results of the examination and then the real content of the boxes, which were examined, was revealed. In the case of an error, its cause was analyzed. Evaluation partly consists in setting-up optimum algorithm for the determination of elements in the box.

In the next test students received more complex boxes, and they were again asked to find-out the content of the boxes using their experience and found algorithm. Black boxes which we constructed using empty tubes for pills [3] contained following circuits:

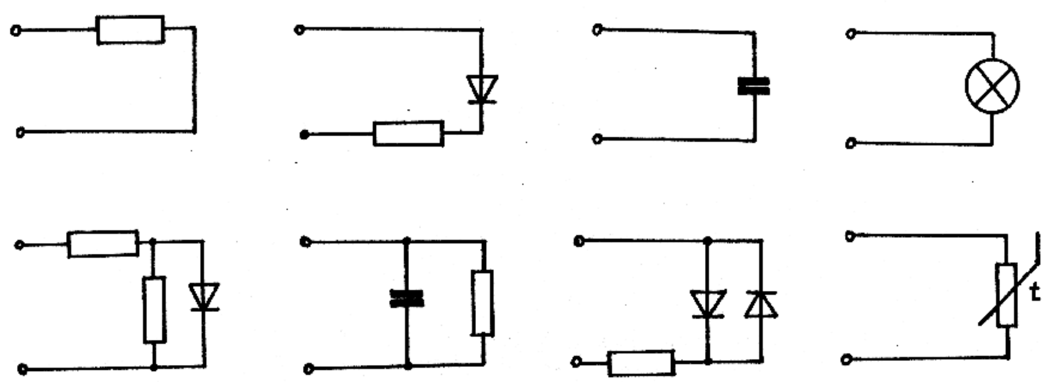

Fig.4: Circuits contained in the black boxes

Groups again consisted of 3-4 students and they were asked to determine the content of boxes within 40 minutes. Not all groups were able to determine the content of all boxes within the given time period and the average rate of success was 61%. To this relatively good result contributed group form of teaching and when the problems would have been solved by individual students the rate of success would be probably lower.

In this test students had mostly no problems with determining particular elements. They had some problems in determining more complex circuits or in distinguishing between resistor, thermistor and bulb. Students had to apply their theoretical knowledge and to realize that it is necessary to change the values of voltage and, eventually, to draw a diagram to be able to determine correctly the elements in the boxes.

What value do students get from these experiments? The most important we consider that they can plan systematic method of investigation and consequently draw meaningful conclusions about the contents of a box. Manipulation with boxes was an attractive task for students who welcomed such a possibility of checking their knowledge and enjoyed their successes. They appreciated the possibility to get acquainted practically with this method and some of them even tried to find other possibilities of using this method in teaching physics.

Conclusion

As the results from research in cognitive science and education show, meaningful learning , in the sense that students are able to interpret and apply knowledge, requires significant active engagement by the learner. In the contribution, we tried to show possible ways of active learning, realised through microcomputer-based laboratory or black box method. These methods encourage student´s activity to ask and answer their own questions, to express their predictions, test their hypotheses and to communicate results to peers. Such active methods help to understand the nature of science better as well as they anticipate the work environment the students will enter upon graduation [5].

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