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THE ROLE AND SIGNIFICANCE OF THE PHYSICS LABORATORIES IN PHYSICS EDUCATION AS A TEACHER GUIDE

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ABSTRACT

The importance of laboratories in physics education has been worked with tradition (TM) versus interactive-engagement (IE) methods. The study was focused on Socratic Dialog Inducing (SDI) methods. Research participants were 625 prospective universities students. Research instruments related with different experiments carried out in mechanic, optic and electricity laboratories have been implemented in three different universities at different stages in different disciplines and the findings have been discussed.

Key Words: *Role of Physics Laboratory, Physics Education Methods, Socratic Dialog Inducing.*

ÖZET

Fizik eğitiminde laboratuarların önemi, klasik yöntem ve soru cevap yöntemi ele alınarak çalışılmıştır. Çalışmada Socratic Dialog Inducing Labaratuvar metodu üzerine odaklanılmıştır. Farklı üniversitelerden farklı bölümlerden 625 öğrenci, mekanik, optik ve elektrik deneylerine katılmıştır. Bulgular sonuçta tartışılmıştır.

Anahtar Sözcükler: *Fizikte Laboratuarın Rolü, Fizik Eğitim Metodları, Socratic Dialog Inducing*

1. Introduction

It has been worked intensively on physics education research in last two decades [1-6]. Physics is an exact science and its real home is the laboratory (lab). The real understanding of physics can not be acquired without lab experience. The purpose of the physics lab is to supply the practical knowledge

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for a complete understanding of the subject of physics and connects practice and theory in physics [7, 8].

The education lab has been used as instructional tool in physics classroom for many years. The role of the lab in science education was emphasized by Blosser [9]. The educational lab has been a common characteristic of introductory courses since 1800s and has received special emphasis during the reforms of the 1960s [10]. Modern physics educational lab positively effects on the learners. Making use of a pretest/posttest, it was demonstrated to influence the effectiveness of lab exercises [11]. The effectiveness of an instructional program about lab was evaluated and lab exercises strongly emphasised on physics education [12]. Science education in some European and USA countries has highlighted educational labs during a century. According to the physics researchers and educators, the labs look like experimental practise of science, and it provides the students possibilities to relate to phenomena in way not possible in seminars and lectures [13]. In Turkey, the university entrance exams are done by test methods and exam questions do not include labs subjects. Before students enter the university they have rarely done lab experiments in the schools. In the university entrance exams, students are the most unsuccessful in science questions. In the years of 2001, 2002, 2003, 2004 and 2005 the average of science questions in the university entrance exams in Turkey is the 4.15/45.00, 4.72/45.00, 5.60/45.00, 4.80/45 and 3.90/45.00 [14], respectively. That is the lowest grade among the courses. According to the results, not only in university entrance exams but also at the universities this poor performance goes on. When content of physics course is presented in theoretical lectures, students can not sufficiently understand the subjects. As this method does not arouse interest of students, it reduces their attendance, because of the fact that the knowledge of theoretical courses is supported by experiments. If the learning becomes more active, it will be lasting and can not be forgotten easily.

Previously researchers were emphasized about the importance of learning of physics education [15]. Physics education labs contribute; 1) increasing one's knowledge, 2) memorizing and reproducing, 3) applying, 4) understanding, 5) seeing something in a different way, and 6) changing as a person. So the last two decades, some physics education labs methods have been developed [2, 3, 5, 11, 13, 14, 16, 17]. In this working, traditional and active-engagement lab methods are compared. The studies were carried out on the mechanics, optics and electricity in the physics labs experiments at the physics education. Here, the article is focused on SDI physics lab. The remaining sections of this paper are organized as follows: The education of lab methods, education of lab assistants, organization of laboratories, handicaps of labs, and student performances, findings and suggestions.

2. Educational Laboratories Methods in Science Education

Educational labs are generally divided in two types; Traditional lab activities and Active-engagement lab activities.

2.1. Traditional lab activities

The students generally perform the actions in step-by-step manner. The goal of these labs are basically demonstrated the correctness of a certain textbook equation [18]. Traditional lab activities was called "cookbook" by some authors [19]. Cookbook labs provide the detailed instructions with no reflective questions and discussion integrated into the experimental procedure fill-in-the blank data tables, and specific questions that happen after the experiment is completed.

2.2. Active-engagement lab activities:

It includes the progressive of physics education labs in the last two decades. In this lab exercises, student active engagement and exploratory investigation characterise the labs [20]. This type of labs is oftenly called generate exploratory lab or open inquiry lab [21] or guided discovery [22] or interactive-engagement lab [21, 23]. In this lab activity, the students are guided in their study by carefully designed instructions teacher. Among the curricular project progressive education labs:

1- The Modelling workshop Project [24].

2- Real Time Physics [6].

3- Tools for Scientific Thinking [25].

4- Microcomputer-Based Laboratory [11].

5- Socratic Dialogue Inducing Laboratory [26].

Here we are focusing on the Socratic Dialogue Inducing (SDI) Laboratory.

2.3. Socratic Dialogue Inducing Laboratory (SDI labs)

SDI labs were originally inspired by the work of Arnold Arons [14]. SDI labs have been shown by pre/post testing to be one of the more effective methods [2, 16, 17, 27, 28]. The advantages of SDI labs:

a) SDI labs emphasize hands-on and heads-on experience with simple experiments. SDI labs are;

1) influenced to students mental construction of concepts, which are promote extensive verbal, written, pictorial, graphical, diagrammatic, and mathematical analysis of concrete of physics experiments.

2) repeated the experiments at increasing level of sophistication.

3) adaptable to a wide range of student populations-high school and university.

4) well received and popular with students.

5) easily modified to go well with students local conditions.

6) well-matched with other interactive-engagement methods.

7) inexpensive and basic equipments are concerned.

8) collaborated peering instructors.

b) SDI labs are attempted to emphasis on concepts for students. They;

1) understanding of the nature of science,

2) use of effective strategies for scientific thinking and problem-solving,

3) provide good training grounds for instructors,

4) are good examples of inquiring learning for prospective teachers,

5) are a source of valuable research data on physics learning, especially pre/post testing is performed and dialogues and conservations are recorded and analyzed.

6) research ability such as collaborative afford, drawing, written description, drawing, thought experiments, modelling, experimental design, control of variable, dimensional analysis, and solution of real-work problems.

c) Students work through lab manual, which encourage active student thinking. Here, a simplify electricity experiment was chosen, which was performed in physics lab. Generally the following steps applied:

Experiment : Connection of Resistors

Object : To learn how to measure the resistance of the resistors, which are connected in series and parallel?

Apparatus : A low DC voltage power supply, three different resistors (30, 60, 90) Ω, DC voltmeter, DC milliammeter (0-600) mA, a rheostat (0-30) Ω or potentiometer (0-60) Ω, cables (red and black), and crocodiles.

Theory : Series connection: $R_{equal}=R_1+R_2+R_3$, parallel connection:

$$\frac{1}{R_{equal}}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$$

Measurement

a) Series Connection: Using the apparatus and cables listed above; make the connection of three resistors in series. Use the rheostat as a potential divider. In order to keep the temperature constant in the resistors, protect against to electricity shock, you should work with the small amount of current. Connect the voltmeter in parallel and milliammeter to resistors. Have your circuit examined by the instructor. Apply the voltage and the record the current through the circuit. Ohm's Law can be used to determine the resistance of resistors R_1, R_2 and R_3. Fill the data in table and using Ohm's Law, compute R_{equal} and compare R_{aqua} with $R_1+R_2+R_3$. Repeat the procedure three times with different voltages.

b) Parallel connection: Connect the resistors R_1 and R_2 in parallel, and voltmeter and milliammeter connect as parallel and series, respectively. Apply the voltage, and record the voltage and current in resistors. Compare the voltage in resistors, and I_1+I_2 with total current i.

Errors: Calculate the absolute errors, $\Delta R=R_{eq}-R_{reel}$, relative error=$\frac{\Delta R}{R_{eel}}$,

percentage error %=$\frac{\Delta R}{R_{eel}}.100$

* As the experiments proceed, discuss with other students and then take note answers to questions, which are related with basic conceptual

understanding of Ohms Law, series and parallel connection in electricity circuit.

* If confused on any of the above (after discussions with other students) engages in Socratic Dialogue with an instructor.

3. Methods in text

Participants was applied approximately on 625 students, which are at the age of 18-19 years, in different disciplines and times at first, second, and third terms. In order to provide equivalence at three universities, common labs experiments (nearly using same equipment, and in equal time) were chosen and same sheets were given to the lab instructors and students. Sheets include generally 8-12 questions.

Basically the questions include; a) aim of experiment, b) information about some experiment equipment, c) theoretical concepts about the experiment (analytical expressions, units), and c) conclusions (graphical analysis, error calculation).

Experiments were done by the students under the control of the experienced and inexperienced assistants who with no intervention by the instructors. During the second experiment, many students had generally complained about inexperienced assistance. As a result of these, in order to increase success, the following lines were determined; a) education of lab assistants, b) lab organisation, c) handicaps at the lab, and d) students performance.

3.1. Education of Lab Assistants

Assistants are the primary instructors, who directly relate the education of the students. They are also the most concerned about the students. So, first they have to be trained by experienced instructors, technology and internal trainings because each of them is an educator. Science educators at all levels need to continue to study the role of the laboratory in science teaching. The activity of the student, the supporters' nature of the experience, and the individualization of laboratory instruction should contribute positively to learning [10]. Some researchers studied about them [12, 17, 28, 29]. This education can be given through; pedagogic education, which is given by seminars and labs education in the field subject. The later;

i- theoretical subjects, given theoretical information and analogise with other subjects,

ii- lab equipment, given information about using equipment, the small problems of equipment and how the problems can be eliminated,

iii- preparing of experiments, controlling the experiment equipment before starting the experiment,

iv- applying experiments

- experiment the instructor has to demonstrate the experiments and question to the inexperienced assistance,
- experienced instructor and inexperienced assistants have to demonstrate/implement the experiment it together,
- inexperienced assistants have to perform the experiment alone and own and explain to the instructor,
- show that the necessary demonstrations and experiments have been done,
- show that up to date development of scientific labs facilities have followed the scientific seminar and meeting.

3.2. Laboratory Organization

Labs organization is important for a successful experiment. Students can enjoy working at well-organized labs, which positively influence the study of labs experiments. Although education labs have been working by low voltage, some students (especially girls) are restless in electricity experiments because of electricity shock. So, lab organisation and proper use of equipment have an important role to play in creating a relaxing atmosphere. If the equipment is simple, not dangerous, and well organized, it helps to the examiner.

3.3. Laboratory Handicaps

Science education researcher have examined the role of the laboratory on many variables, including achievement, attitudes, critical thinking, cognitive style, understanding science, the development of science process skills, manipulative skills, interests, retention in science courses, and the ability to do independent work. Continuity and consistent habits are important in working at physics education labs. Doing experiments should begin in the early years of teaching and education and continue at each step of teaching. Good habits can be transformed to the research. For the last forty years, there have been many lab problems in physics education (like another science in Turkey). At each level of education and teaching training in labs or physics is not enough. There are many reasons for this. Generally these reasons are: a) crowded classes, b) unstableness of labs at school, c) inefficiency of equipment at labs, d) labs experiences don't continue, e) university entrance exams have a test system which doesn't include labs subjects. Working, so labs experiences are not given importance. As a result, instead of a long-period education, a short period one is emphasized; a) students think that the time they spend in labs is a waste of time. They prefer memorizing short period knowledge, b) labs experience isn't a requirement for the students to pass their exam, d) curriculum is too intense, but some of courses are unnecessary, e) assistants are not educated enough, f) control system is not enough.

As far as I know, if the conditions, above, are removed, students will realize the importance of physics lab experience.

4. Students Performances

In order to determine the best average level of students, from the classical to the up to date methods, the following methods were applied.

A
- assistants explain the experiments to the students,
- each of the experiment groups has four or six students,
- assistants have two groups of students,
- tests are given to the students at the end of the term.

B
- A steps are applied, but difference,
- each of the experiment groups has two students,

C
- A steps are applied, except for last step,
- post test is applied at the end of experiment.

D
- before the starting of experiment, a pre test is given to half of the students,
- experiment groups are prepared by assistants and students together,
- each group has two students,
- assistants have two groups of students,
- post test is given at the end of the experiment.

E
- **D** are applied, except for the post test. Students prepare the reports about experiments and they take the tests after they have submitted their reports.

F
- **E** steps are applied, except for the post test. Post test is given at the end of term.

5. Statistical Analysis

Among different each of the educational methods of mean values was calculated by a one-way ANOVA test. The comparison was performed using Turkey-HSD test. A P value two tailed <0.05 was accepted as significant. According to the results of the statistical analysis, each method shows difference, such as A is differed B, C, D, E, and **F**.

5. Findings

In this study and previously studies show that lab experiments positively contribute the learners, such as understanding science, critical thinking, manipulative skills, inquiry-discovery, and problems solving-ability in physics [10]. The lab activities are interested in having students inquire and in having them work with concrete objects.

The findings show differences at different departments and universities. Also these differences are not the same in the applied methods. Also they show differences in subjects. Instructors have examined the role of physics lab on some variables. Lab experiments positively contribute the learners, such as understanding science, critical thinking, manipulative skills, inquiry-discovery, and problems solving-ability in physics. During the lab experiments, assistants expressed that they have also learned something from students when they have listened the students. One important mistake of students is the plotting of a graph. It is clearly understood, although the details are given about experimental information, students can not plot graphs properly. They can not arrange the interval of numbers on the scale. Also they make mistakes connecting points. Instead of finding the average of points, students try to show the average point by point.

The following findings are obtained percentages for applied methods. The test results are given in

A • In this method, success percentage is the lowest. It is nearly 28.55%. The reasons for this:

- crowded groups
- since the students didn't set up the experiments, themselves, they don't have enough information and experience about the experiments,
- assistants didn't sufficiently assist the students because of crowded groups,
- in the crowded groups, some students didn't do experiments, they watched other friends and became idle onlookers,

B • In this method, the success is slightly increased according to A, at about 32.10%. The reason of increase is that the number of students in B is less than A. So, the students did the experiments themselves and assistants helped students when it was needed.

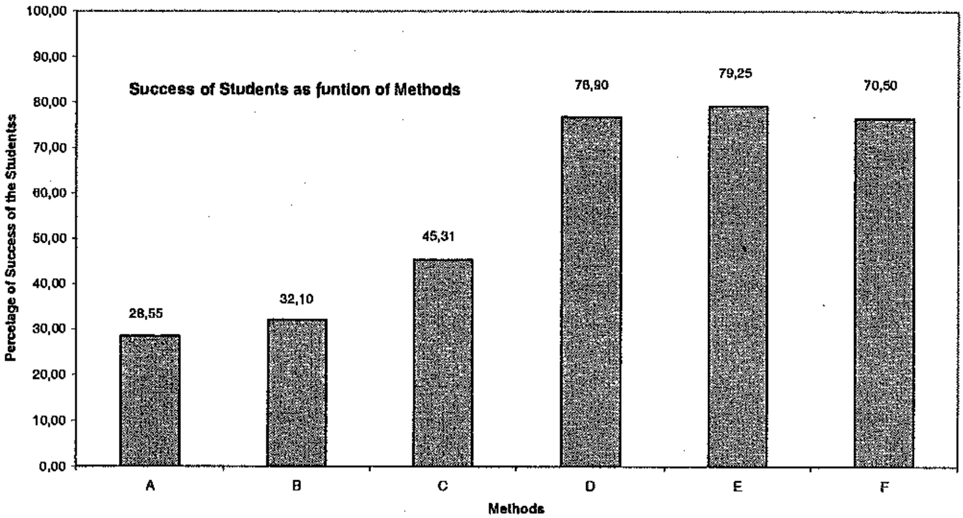

Fig.1. Percentage of the success of the students versus methods. Note that the method of E shows the highest success.

C • Here, the success is approximately 12.90% higher than B. The reason for this is asked to the students and assistants. They express that the number of students is reasonably less and the students have taken the post test when their knowledge is fresh.

D • In this step, increase the success is fairly higher than before methods, nearly 76.90%. Pre test is applied a half of another group of students. In this time, the success is a bit higher. Because, the students were familiar the events and some of students may have missed important points and they had some revised Information.

E • In this method, findings showed that it Is nearly 79.25%. In this period, some students had the chance at keeping up with the other students.

F • The results show that there is not much difference between D and E, which is 76.50. The little difference is due to the time passed. it is obvious that knowledge obtained with active learning lasts longer.

6. Suggestion

From findings, above, in order to increase, the following are needed; a) education of assistants, b) organization of labs and equipment of experiments, c) giving information about arrange the numbers on the scale and plotting graph and analysis of graph, error and accuracy, d) giving information about experiments before hand, e) giving calculation of error percentage, f) preparing report of experiment, d) study of assistants fewer students in groups, and f) method of IE, SDI labs are fairly important.

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