Effects of Strategy Instruction in Cooperative Learning Groups Concerning Undergraduate Physics Labworks

Fatma Keban[1] and Mustafa Erol[2]
[1]The Institute of Educational Sciences, Dokuz Eylül University, 35160, Buca, İzmir, Turkey.
[2]Department of Physics Education, Education Faculty of Buca, Dokuz Eylül University, 35160, Buca, İzmir, Turkey.

E-mail: fzkeban@yahoo.com

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Abstract

This work investigates effects of strategy instruction method applied within cooperative groups on the student academic achievement and retention level. Instructional methods specifically contain conventional labwork techniques applied to the control group students and strategy instruction within cooperative groups that is applied to the experimental group. In the work, pretest-posttest quasi-experimental design with nonequivalent control group was used and the research was carried out on two separate groups consisting of first grade undergraduate students (n=39). Data of the work was collected by means of Introductory Physics Laboratory Achievement Test (IPLAT). The entire work covers some selected Electricity and Magnetism topics. During the application, the control group students carried out close ended experiments while the strategy instruction group students carried out a semi open ended experiments with 12 strategic steps. The evaluation of the research indicates that strategy instruction increases student academic achievement and it has also positive effects on the retention level. However no statistically meaningful difference between control and experimental group students concerning academic achievement and retention level is detected.

Keywords: Physics Education, Physics Labwork, Cooperative Learning, Strategy Instruction, Academic Achievement, Retention.

Resumen

Este trabajo investiga los efectos del método de enseñanza aplicado en la estrategia de grupos cooperativos en el logro académico de los estudiantes y el nivel de retención. Los métodos de instrucción contienen específicamente las técnicas convencionales de análisis de laboratorio aplicados a los estudiantes del grupo de control y enseñanza de estrategias dentro de los grupos de cooperación que se aplica al grupo experimental. En el trabajo, el diseño pretest-postest quasi-experimental fue utilizado diseñando un control de grupo con no equivalentes y la investigación se llevó a cabo en dos grupos separados que consiste de los primeros estudiantes de licenciatura de grado (n = 39). Datos de la obra fue recogida por los medios de Introducción a la Física Laboratorio de Prueba de Aprovechamiento (IPLAT). Toda la obra cubre algunos temas seleccionados de Electricidad y Magnetismo. Durante la aplicación, los estudiantes del grupo de control concluyeron sus experimentos, mientras que la estrategia de instrucción del grupo control llevó a cabo un semi experimentos de composición abierta con 12 medidas estratégicas. La evaluación de la investigación indica que la instrucción de estrategias aumenta el logro académico de los estudiantes y tiene también efectos positivos en el nivel de retención. Sin embargo no hubo diferencia estadísticamente significativa entre los estudiantes del grupo control y experimental sobre el rendimiento académico y el nivel de retención detectado.

Palabras clave: Educación Física, Trabajo de laboratorio de Física, Aprendizaje cooperativo, Enseñanza de estrategias, Logros académicos, Retención.

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I. INTRODUCTION

There has been an ever increasing interest on physics education in the last decade, physicists and physics educators focus on "how to teach in a better way?" In addition to conventional and contemporary physics research, strategy instruction is one of those promising and hot topics of physics education research. Especially strategy instruction in physics labworks is crucial considering the importance of labworks in physics education.

The purpose of labworks in science education includes helping students learn science through the acquisition of conceptual and theoretical knowledge, and helping them learn about science by developing an understanding of the nature and methods of science. Labwork also enables students to do science using the protocols of scientific inquiry. The increased support for purposeful learning complements scientific theories and how to apply them. Furthermore, labworks should stimulate the development of analytical and critical skills and create interest in science [1]. A laboratory has to provide the opportunity for students to discover physics rules [2]. Lunetta attributes the obvious difference between demands and achievements in school labwork to a mismatch between teachers' and students' aims [3]. That is aims, related to labwork in science education, and in opposite aims, students actually follow when taking part in labwork. [2].

Constructivist model of learning recently attracts much interest and new curriculum materials are being developed and administered all over the world. Constructivism in education means the novel knowledge is linked to the existing once and new knowledge block is created by the learner. Strategy instruction is considered as one of the sub topics of constructivist learning model. One of the most important key elements of the strategy usage in education is to force the students to enter the actual process. This obviously depends upon students' knowledge of the strategy. The word of "strategy" has a military origin and it is defined as "the shortest way to achieve a goal" [4, 5]. Thus, the ways learners should follow for effective learning can be explained with the concept of learning strategy in literature [6]. The learning strategies are the means that the learners use to realize their own learning goals. In literature, although there is a consensus about the significance and effectiveness of learning strategies, which are mostly called as "cognitive strategies", there is no such agreement about a certain definition and classification of these strategies. Weinstein and Mayer described several techniques that the student can be taught to use to facilitate the learning process. These techniques are referred to as learning strategies, and are defined as "behaviors and thoughts that a learner engages in during learning and that are intended to influence the learner's encoding process. Thus, the goal of any particular learning strategy may be to affect the learner's motivational or affective state, or the way in which the learner selects, acquires, organizes, or integrates new knowledge. (p. 315)"

Weinstein and Mayer (1986) presented eight categories of learning strategies [7]:

1. **Basic Rehearsal Strategies:** Rehearsal Strategies, such as repeating the names of items in an ordered list, are useful for such tasks as remembering the order of the planets from the sun.
2. **Complex Rehearsal Strategies:** These strategies include copying, underlining or shadowing the materials presented and are useful for tasks such as studying the cause of World War II.
3. **Basic Elaboration Strategies:** Forming a mental image or sentence relating items in pair of items is an example of strategies useful in tasks such as forming a phrase or sentence to relate the name of a state and its major agricultural product.
4. **Complex Elaboration Strategies:** The aim of the strategies is to connect previous knowledge and new concepts.
5. **Basic Organizational Strategies:** Grouping or placing with respect to certain specifications relating in a list of instructional concepts are the strategies in this section. Usage of these strategies makes students to get involved with the actual learning activities.
6. **Complex Organizational Strategies:** More complex tasks, such as outlining a sight chapter in a text, required being able to outline a passage or create a hierarchy.
7. **Comprehension Monitoring Strategies:** Comprehension monitoring includes checking for failures to comprehend and is demonstrated in school tasks when the student uses self questioning to check understanding materials in class or text
8. **Affective and Motivational Strategies:** Included here are techniques such as relaxation when test-anxious or using thought-stopping to prevent thoughts of doing poorly from directing the learner's attention away from the material to be studied

The problem statement of the present research is: what are the affects of labwork constructed by strategy instruction on academic achievement and retention level relating the topics of electricity and magnetism.

II. METHOD

A. Research Model

In the work, pretest-posttest quasi-experimental design with nonequivalent control group was used. This work is considered as a "case study" and hence is not related with any universe.

Data of the work was collected by means of Introductory Physics Laboratory Achievement Test (IPLAT). Independent variable of the research is determined as teaching method. Dependent variables of the study are academic achievement and level of retention.

B. Participants

The research was carried out on two groups consisting of first grade students (n=39) at undergraduate level all attending Introductory Physics II Lab course.

Electricity and Magnetism are imported subjects of Introductory Physics Lab Courses, taken during the second semester for Elementary Science Education Departments at Dokuz Eylül University.

All of the students in the sampling are registered according to their scores of national university entrance examination. So they had nearly same scores and cognitive levels. Randomly selected classes of A and B, both including 39 students, are considered as control group and experimental group. Experimental group includes 14 girls, 6 boys and control group includes 12 girls and 7 boys. In the beginning of the experimental work, to determine difference in academic achievement between experimental and control group students, a self-prepared achievement scale was administered to both groups. Table I shows scores obtained from the achievement scale, used as a pre-test, were assessed by applying Mann-Whitney U test.

TABLE I. Mann-Whitney U test data indicating the relation between pre-test scores of experimental and control group students that is obtained from Introductory Physics Laboratory Achievement Test (IPLAT).

Groups	n	Mean Rank	Sum of Ranks	U	Significance Level*
Control Group	19	15.78	252.50	116.50	P=0.48*
Experimental Group	20	18.15	308.50		

Table I indicates that there is no significant difference on average achievement points for experimental and control group students. Hence, it is found that prior to the research, electricity and magnetism topics achievement of students at both groups were almost equal.

TABLE II. The table showing the sub domains of psychomotor field, strategic steps and relating explanations.

Sub Domain	Strategic Step	Explanation
Perception	Determination of physical principal	Expected to be achieved by the students
Perception	Answering questions	Determined by the instructor and relating question is asked to the students
Set	Security work	Achieved by the students
Set	List of components for the set up	Determined by the instructor and the list given to the students
Set-Guided response	How to use a certain device	Expected to be known by the students with the help of instructors when needed
Guided response	Designing experiment	Expected to be achieved by the students
Mechanism	Setting up the experiment	Expected to be achieved by the students
Complex overt response	Specific hand on activities	Determined by the instructor and expected to be achieved by the students
Complex overt response	Drawing tables and graphs	Expected to be achieved by the students
Complex overt response	Theoretical calculations and comparison with experimental data	Expected to be achieved by the students
Complex overt response	Evaluation of the results	Expected to be achieved by the students with the help of instructors when needed

C. Strategy Instruction Materials

Labworks in any experimental science intends to improve all instructional domains namely cognitive, psychomotor and affective domains. However, the most fundamental of all is the psychomotor domain. Objectives in psychomotor domain are directly related to improve coordination between consciousness and physical abilities. It is initially explored sub domains of psychomotor instructional field which are perception, set, guided response, mechanism, complex overt response, adaptation and origination. Considering specific requirements of physics labworks led us to determine the following guidance strategic steps to apply throughout the entire application period for any individual topic [8]. The following table shows the details of the strategic steps.

Instructional materials specifically developed on the following sub topics: 1. Direct current 2. Analyses of direct current circuits, 3.Magnetic field and 4. Magnetic force. Considering the sub domains and strategic steps given in Table II, following 12 strategies are developed by the researchers:

Strategy 1. Determination of the physical principal.
Strategy 2. Answering the questions about the experiment.
Strategy 3. Check necessary security steps relating the experiment.
Strategy 4. Recognizing components used in the experiment.
Strategy 5. Expressing when and how a certain component is used.
Strategy 6. Designing the experiment.
Strategy 7. Drawing the actual set up.
Strategy 8. Setting up the experiment.
Strategy 9. Performing specific hand on activities.
Strategy 10. Express the results of the experiment by means of tables or graphs.
Strategy 11. Perform theoretical calculations and compare them with the experimental data.
Strategy 12. Evaluate the overall results.

D. Data Collection

Introductory Physics Laboratory Achievement Test (IPLAT). In order to get an answer for the problem situations, "Introductory Physics Laboratory Achievement Test (IPLAT)", which was developed by the researchers, was used. This scale aims to measure academic achievement of students and the level of retention of knowledge regarding the electricity and magnetism topics.

During the development of the scale, firstly 40 multiple choice questions were prepared. The question of the scale consist of Direct current, Analyses of direct current circuits, Magnetic field and Magnetic force. The questions have five options. Test was analyzed and answered by the researcher and an expert for comprehensibility of questions, determine the solution time and search the content validity. After analyzing, necessary changes and corrections have been made on the test. Time needed for the IPLAT was determined about 80 minutes.

IPLAT applied to 97 students which attend Education Faculty of Buca and had introductory physics course for reliability confidence study. IPLAT is computed in terms of the items' difficulty, discrimination index by means of Test Analysis Statistics Program (TAP). In this case KR-20 confidence parameter is calculated as 0.76.

The Items with discrimination index less than 0.20 is initially removed from the test. Hence 15 items removed and the final version of IPLAT is made up of 25 items with a KR-20 reliability coefficient of 0.78(SD 4.685).

Remaining 25 items have a discrimination index of 0.28-0.62 with a mean value of 0.45 difficulty index of 0.21–0.88 with a mean value of 0.55. The maximum point of the IPLAT is 25 and approximate answering time is about 50 minutes.

E. Data Analysis

The collected data from the IPLAT were analyzed by SPSS, 11.0 for Windows statistic program. Frequency, percentage, mean (*M*), standard deviation (*SD*), t-test were employed during the analyses. All statistical tests reported in this paper were conducted with a significance level of $\alpha = 0.05$. In order to test the significance of the mean values for the variables nonparametric tests (Mann-Whitney U Test, Wilcoxon Signed Rank Test) are employed due to having few students in each group.

III. RESULTS AND DISCUSSION

This section includes findings obtained from IPLAT applied as pre-test, post-test and delayed- test to both group of students.

A. Effects of Strategy Instruction on Academic Achievement

At the end of the experimental study, in order to detect any improvement on academic achievement for the experimental and the control group students, Wilcoxon Signed Rank Test applied to pre and post test results. The figures are presented in the Table III and pre-test datum were evaluated using Wilcoxon test as shown.

TABLE III. Wilcoxon Signed Rank Test Results.

Groups	Ranks	n	Mean Rank	Sum of Ranks	z	Significance. Level*
Control Group	Negative	0	0.00	0.00	3.63	P=0.00*
	Positive	17	9.0	153.00		
	Ties	2				
Exp. Group	Negative	0	0.00	0.00	3.92	P=0.00*
	Positive	20	10.50	210.00		
	Ties	0				

Note :Posttest<Pretest: negative ranks Posttest>pretest: positive ranks.
Post test=pretest: ties
*Significant ($p < 0,05$).

According to the data given in Table III, it is found that there is a significant difference between pre-test and posttest achievement score averages of students for both groups and this difference is in favor of post-test scores.

With the aim of comparing effectiveness of applied teaching and learning methods on academic achievement, emergence of a probable difference in academic achievement of magnetism topics between experimental and control group students were analyzed. For carrying out this analysis, post-test achievement scores of the students were evaluated using Mann-Whitney U test as shown in the Table IV.

B. Relation Between Control and Experimental Group Students Concerning Post Academic Achievement

TABLE IV. Mann-Whitney U test data indicating relation between post-test IPLAT achievement scores of experimental and control group students.

Groups	n	Mean Rank	Sum of Ranks	U	Significance Level*
Control	19	17.06	273.00	135.00	P=0.97*
Experimental	20	16.94	288.00		

**Not Significant ($p > 0,05$).*

According to the Table IV, at the end of the application, it is found that there is no significant difference between post-test achievement score averages of experimental and control group students obtained from the scale. Considering the results presented above the following conclusion can be drown.

Strategy Instruction within cooperative groups has no positive effects compared to conventional instruction method on academic achievement concerning fundamental physics Labworks.

In the research, IPLAT applied to experimental and control groups as pre-tests and the mean values of the groups are found to be very close to each other. This means there is no statistically meaningful difference between the groups before the application. After the application, IPLAT reapplied to the both groups as the post-tests. According to the results of post-tests both labworks have positive effects on the academic achievement of the students. However no meaningful difference has been detected when post tests results are compared. This result supports some of the previous findings on cooperative learning in laboratories. For instance Burron et. al. investigated the relation between cooperative and conventional labworks and found that there is no meaningful difference on physics labworks concerning academic achievement [9]. Chang and Lederman used conventional laboratory approach to one of the three classes and cooperative laboratory approach to two of the three classes. At the end of the research, they found no meaningful difference on academic achievement between three groups [10].

Nevertheless some works indicate that cooperative learning in labworks increase the academic achievement [11, 12, 13, 14]. Those of Cox and Junkin III searched effects of peer instruction and cooperative learning concerning labworks. At the end of the research they found that the academic achievement is increased by %50-100 in the experimental group compared to the control group.

In the literature many works about effective learning on physics prove that active learning increase students' academic achievement. Altınok (2004) investigated effects of cooperative conception mapping, personal conception mapping and conventional instruction methods on students' science achievement and strategy use [15]. In his work one of the groups had cooperative conception mapping, another one had personal conception mapping and the last one had conventional instruction. Before the application conception mapping group is educated about conception mapping strategy. The evaluation of the results indicate that; 1. conception mapping strategy has positive effects on students science achievement than conventional instruction., 2. conception mapping has positive effects on using learning strategy than conventional instruction. Also Ergün (2006) searched effects of cooperative learning method and ordinary learning method on science lesson achievement [16]. In the work collective learning technique is applied in the experimental group and conventional teaching techniques are applied in the control group and it is found that the academic achievement is meaningfully higher in the experimental group.

According to our view, the reasons of having about similar academic achievement at the end of the research can be summarized as follows: 1-The application is carried out within for weeks which is reasonably short period, 1-The crowdedness of the groups (five students) due to the shortage of the equipment. 3-Having inexperienced instructors.

In the literature there is a little research about strategy instruction in physics laboratories. Labworks contribute to doing effective physics instruction. In order to internalize concepts and laws of electricity and magnetism or in general physics its very beneficial to force students to mobilize the preconceptions learned previously and try to plan labworks including all the steps namely planning experimentation concluding.

C. Effects of Strategy Instruction on Retention

The same scale was administered four weeks later as a delayed-test in order to determine whether there was a difference between academic achievement of the students and to determine the effectiveness of the applied teaching and learning methods on retention levels.

For comparing the effectiveness of applied teaching methods on retention level, the relation between average post-test and delayed-test achievement scores for both experimental and control group students, Wilcoxon test was used as shown in the Table V.

According to the data given in Table V, there is no statistically significant difference, with $\alpha = 0{,}05$ significance level, between average post-test achievement scores and average delayed-test achievement scores for both experimental groups and control group students.

TABLE V. Wilcoxon Signed Rank Test Results.

Groups	Ranks	n	Mean Rank	Sum of Ranks	z	Signific. Level*
Control Group	Negative	9	9.33	84.00	1.37	P=0.17*
	Positive	6	6.00	36.00		
	Ties	4				
Exp. Group	Negative	9	6.72	60.50	1.05	P=0.29*
	Positive	4	7.63	30.50		
	Ties	7				

Note: Retention<post test: negative ranks Retention>Posttest: positive ranks Retention=post test: ties
**Significant* ($p > 0{,}05$).

For determining whether there was a difference between retention level for both group of students, the student achievement scores obtained from delayed-test were evaluated using Mann-Whitney U test as shown in the Table VI.

TABLE VI. Mann-Whitney U test data indicating relation between delayed-test IPLAT achievement scores of experimental and control group students.

Groups	n	Mean Rank	Sum of Rank	U	Sig. Level*
Control	19	15.97	255.50	119.50	P=0.55*
Experimental	20	17.97	305.50		

**Not Significant* ($p > 0{,}05$).

According to the data in Table VI, it is found that there is no significant difference between delayed-test achievement score averages of the experimental and control group students. The overall conclusion here can be drawn as: **Strategy Instruction within cooperative groups has no positive effects compared to conventional instruction method on retention level concerning fundamental physics Labworks.**

This results tell us both control group and experimental group students keep their obtained knowledge even two months later the applications.

According to the results of delayed-tests experimental group students' mean values higher than control group students' mean values. However no meaningful difference has been detected when delayed tests results are compared. For this reason we can say that both groups keep their post tests achievement level and both two labworks have positive effects on students' retention. This result supports some of the previous findings on labworks, strategy instruction and cooperative learning. For instance Öner and Arslan [17] used a strategy method on six grade students for electric unit. At the end of the research, they found meaningful difference on learning and retention level. Nevertheless some works indicate that cooperative learning in physics education has positive effects on retention [18, 12, 13, 14].

Çopur [19] enrolled that Johnson et. al. access results of 305 researches meta-analyses' data which was practice on university students is following: cooperative learning is effective about student achievement than competitor and individual learning. Results of the work put forward that cooperative learning improves abilities like to obtain information, retention and configuration, to be creative in problem solving. Effects of learning strategies using on academic achievement, retention level investigated by one of the researches about strategy instruction and using. After this research accessed that education with learning strategy instruction is effective increase students academic achievement and retention [20]. Anderson applied direct teaching two cognitive strategies on 5 grade students for four weeks in 1997. At the end of the research seen that strategy instruction increased students achievement and the effect of continued two, four, eight weeks [21].

In our research experimental group students retention level is higher than control groups students retention level. However no meaningful difference has been detected. Both groups delayed tests points are very close. According to this results, we accessed that both labworks have positive effects on students' retention.

IV. CONCLUSIONS

Based on these results we can say that labworks increased students' academic achievement and have positive effects on retention. Again, according to the findings we express that labworks with strategy instruction in cooperative groups can be used as an alternative instead of traditional labworks.

Both the survey of the literature and our experience with this at the end of the study we can construct the following suggestions to the researchers:

1. Literature is examined encountered many research different teaching methods like problem based learning, cooperative learning, research and inquiry-based teaching, problem solving strategy instruction effects of teaching physics topics. However no research encountered relating the effects of strategy instruction in physics labworks on academic achievement and retention. Labworks are very important for physics instruction, hence researchers can study the effects of strategy instruction in physics labworks integrated with physics lessons.
2. Groups in excess of the number of elements, makes it difficult to provision of intra-group interaction and group dependence. The size of the cooperative learning groups should be 3-4 people.
3. Effective strategy instruction for the use in labs, laboratories should be averaged by 12-16 people.
4. To use this method, environments, teachers should be informed about cooperative learning and teaching strategy and students ought to be given seminars on various strategies to help learn and use.
5. Different levels of education, made similar studies, explored the applicability of the method on the education levels.
6. The same research by applying longer-term, efficacy and limitations of this method, ought be determined.
7. Similar studies should also be carried out to examine the effects of the method on variables such as students' attitude, motivation and self efficacy.

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