Effects of Cooperative Learning on Instructing Magnetism: Analysis of an Experimental Teaching Sequence

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Abstract

This paper describes methods and the results of a work designed to analyze effectiveness of an experimental teaching sequence on the topic of magnetism. Cooperative learning techniques were employed to experimental group and conventional teaching method was used for control group throughout the teaching sequence. Sampling of the study consists of 19-20 years old 100 students at a state university in zmir, Turkey. Levels of pre-knowledge acquired by the students were evaluated by means of a self-developed "Magnetism Topics Achievement Scale (MTAS)" and the progress and retention were determined by the same scale. A clear significant difference, as a conclusion, was detected in favor of the experimental group indicating the success of the cooperative learning teaching sequence. Additionally, personal compositions were administered to extract information about the students' views on the overall actual teaching techniques and methods.

Keywords: Cooperative learning, Teaching magnetism, Physics education.

Resumen

Este artículo describe los métodos y resultados de un trabajo diseñado para analizar la eficacia de una secuencia de enseñanza experimental sobre el tema de magnetismo. Se emplearon técnicas de aprendizaje cooperativo con un grupo experimental y se utilizó el método de enseñanza convencional con un grupo de control en toda la secuencia de enseñanza. La toma de muestra del estudio consta de 100 estudiantes de 19-20 años de edad en una Universidad estatal en zmir, Turquía. Los niveles de pre-conocimientos adquiridos por los estudiantes fueron evaluados por medio de una auto desarrollada "Escala de Logros en Temas de Magnetismo (MTAS)" y el progreso y la retención fueron determinados por la misma escala. Como una conclusión, se detectó una clara diferencia significativa a favor del grupo experimental indicando el éxito de la secuencia de enseñanza de aprendizaje cooperativo. Adicionalmente, se administraron composiciones personales para conseguir información sobre las opiniones de los estudiantes sobre el conjunto real de métodos y técnicas de enseñanza.

Palabras clave: Aprendizaje cooperativo, Enseñanza del magnetismo, Educación en Física.

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I. INTRODUCTION

Lecturing is the most common method of instruction in the tertiary levels of education [1]. However, research results of many researchers who focus on teaching various topics of university physics indicated that conventional teaching hardly improves the teaching of principle concepts of physics [2]. Similarly, experiences in this field suggested that even physics education conveyed by a well-prepared presentation do not give effective results through understanding principal concepts [3]. In debates concerning how to increase the learning of physical concepts, many researchers claimed that students need to take part in social interaction [4]. In addition, it was underlined that while teaching physics, it is necessary to use methods which utilize instructional activities that students can think of what they are doing and think of the applications they are carrying out [5]. It is also essential to allow students reflecting their own ideas and prepare an environment giving them a chance to discuss their learning with other students and their teachers [6]. Cooperative learning can be shown as a sample of education of this kind [3] and this method can easily be adapted to the current structure of physics education [5]. On the other hand, Johnson and Johnson [7] indicate that if cooperative learning is used more widely and more frequently, students would learn to be more scientific and come to feel better about themselves as science students. Benefits of cooperative learning, which is defined as "involving three or more children who work together in a group in order to maximize their own and each other's learning" by Johnson, Johnson and Holubec [8], on academic and social gains of students were indicated by various studies [4, 9, 10, 11, 12, 13, 14, 15, 16].

Magnetism is considered as one of the most difficult topics within physics to learn and understand by the students [17, 18, 19, 20]. According to students, these topics contain difficult mathematical operations and they find the most of the concepts relating the topics intangible and can not directly be associated with daily life [17, 18, 21, 22, 23]. In addition, students seem to have very little information about magnetism topics at secondary school level and this situation causes an important pre-information deficiency of first grade university students, in Turkey [24].

A general evaluation of the studies relating teaching magnetism shows us that these studies mainly aim to determine misconceptions of students and the points they have trouble to learn about certain topics. However, a small number of studies suggest learning methods and techniques, which are effective in elimination of these misconceptions, which reduce student difficulties and realize meaningful learning. But these studies are generally limited with some specific instructional studies like problem solving and experimentation [25]. We think that, more better success can be achieve by rendering students active in all stages of instructional process with cooperative learning.

Taking all these points in to account, the purpose of this study is to analyze effects of cooperative learning on academic achievement and on the level of retention of knowledge at graduate level in teaching magnetism topics.

II. RESEARCH QUESTIONS

We formulated following questions in order to measure effectiveness of our experimental teaching sequence:

1. Do cooperative learning techniques have clear advantages concerning academic achievement with respect to the conventional teaching relating magnetism topics?
2. Is cooperative learning more effective than conventional teaching in terms of retention?
3. What are perceptions of students about cooperative learning and conventional teaching?

III. METHOD

A. Research Model

Pre-test and post-test controlled group experimental model is employed in the research. Independent variables of the research consist of cooperative learning and conventional teaching method. Dependent variables of the study are academic achievement, level of retention and finally written ideas of students concerning the application.

B. Sampling of the Study

Sampling of the research consists of 19-20 years old 100 second grade students taking General Physics II course at Primary Mathematic Education Department, in a state university in Izmir. Reason of selecting this sample based on students' background. All of the students in the sample 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 50 students, are considered as control group (class A) and as experimental group (class B). Class B includes 31 girls, 19 boys; and Class A includes 32 girls and 18 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. Scores obtained from the achievement scale, used as a pre-test, were assessed by applying independent samples t-test is shown in Table I.

TABLE I. t-test data indicating the relation between pre-test scores of experimental and control group students that is obtained from magnetism topics achievement scale (MTAS).

Groups	n	Mean	Standard Deviation	t	p	Significance Level
Experimental Group	50	5,02	2,63	0,082	0,935	p > 0,05 not significant
Control Group	50	4,98	2,23			

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, magnetism topics achievement of students at both groups were almost equal.

C. Data Collection

With the aim of finding answer to the research questions, mentioned above, two different data collection tools, which are defined below, were employed.

I-Magnetism topics achievement scale (MTAS)

In order to get an answer for the first and second problem situations, "Magnetism Topics Achievement Scale (MTAS)", 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 magnetism topics.

During the development of the scale, firstly 35 multiple choice questions were prepared. These questions aimed to measure objectives and behaviors determined by the researchers regarding teaching of magnetism topics at the points where students have heavy troubles of learning and misconceptions stressed in the related literature. Following the needed corrections, carried out by two specialists, the number of questions was reduced to 32 and the first draft of the scale was formed. For analysis of comprehensibility and solution time, the scale was answered by 5 academicians from Physics Education Department. Taking the recommendations that came out, the corrections were made and finally the scale was ready for reliability measurement. Reliability study of the scale was carried out by administering to 173 students excluding sampling group. Following the reliability study, 7 questions with low distinctiveness were excluded from the scale. Final form of the scale, includes 25 multiple choice questions, has a KR-20 reliability coefficient of 0.61. The scale does not include habitual questions for 173 students as they generally experienced before. They are usually experienced with mathematical problems that are based on application of concepts and equations. So they fond some questions unusual and difficult. The reliability which seems low might be explained by this reason. Eight of the questions in the scale measure comprehension, 11 of them measure application of concepts and others six measure analyzing and evaluation of magnetism problems. Sample questions regarding these levels are given in Appendix A.

II-Written descriptions

In order to obtain an answer to the third research question, documentary analysis also known as written descriptions, one of the qualitative data collection techniques, was used. At the end of the application, the experimental and control group students were asked to write their own ideas on activities and materials that are applied in teaching of magnetism topics. The students were asked to evaluate effects of applied activities and materials on four separate points, namely their learning, providing permanence of knowledge, providing entertaining course/course participation and their social developments.

Data Collection and Evaluation:

MTAS was applied as pre-test before the application, as post-test at the end of the application and as delayed-test four weeks after the application had completed. In statistical analysis, independent variables t-test, with a significance level of α = 0.05, was used for comparing experimental and control groups in terms of pre and post applications concerning academic achievement and retention level. Paired samples t-test was used for determining academic achievement and retention levels of experimental and control groups concerning internal progresses.

At the end of the application, written comments of both groups of students were received regarding applied activities and materials. These comments were analyzed by the two researchers individually and common ideas summarized under the articles mentioned above.

IV. TEACHING SEQUENCE

A. Teaching Objectives and Behaviors

There are two important factors determining teaching process of the experimental study. The first one is the fact that the students are not from science education department and the other one is the fact that magnetism topics are completed in a period of only four-weeks. In order to make the teaching process convenient to the level of students, firstly essential points were determined regarding magnetism topics. To this end, cognitive, psychomotor and affective objectives/behaviors, suitable for the process and the level of the students, were assigned [25].

B. Content and Order

Topic content and order is simply organized in accordance with determined objectives/behaviors and the level of students. Hierarchical teaching of main concepts and principals and provision of similar concepts and principals together were paid attention in this organization. In text books, it is found that magnetic field is generally introduced by magnetic force on a charged particle moving in a field. However, it is clear that it would not be easy to understand the magnetic force concept by using of a field which they actually have no idea about its reason. Therefore, it is important to explain how magnetic field is formed to start with. At this stage, it is assumed that proceeding from known to unknown would make comprehension of students easier. It is clear that pre-knowledge of the students includes magnet concept, orbital movement of electrons around nucleus and rotational movement of electrons. For this reason, it is considered that it would be beneficial to start explaining how magnetic field is formed in a magnet. Yet, for allowing the teaching of the concept of field in a permanent way, in their study, Chabay and Sherwood [17] focused on the importance of stressing how magnetic field is formed by magnetic dipoles and how dipoles in a material are formed by the applied external field. In their study they stressed that, an atomic model would help students to estimate magnetic moment of a bar magnet. Thus, the students will be able to comprehend that magnetic field is caused by moving charges and also comprehend the magnetic field caused by a moving charge in a conductor easier. While observing the effect of this field to a charged particle, to another current carrying conductor and to a compass they will be able to embody this discrete concept. Therefore, topic content and order is organized as below:

1. Formation of Magnetic Field and Magnetic Features of Materials: How magnetic field was discovered?, magnetic field strength, magnetization and magnetic flux density, magnetic features of materials.
2. Magnetic Field Sources: Biot-Savart’s law, Ampere’s law.
3. Magnetic Force: Magnetic force affecting a charged particle moving in a magnetic field and movement of charged particle in a magnetic field, magnetic force effecting a current carrying wire in a magnetic field, magnetic force between two parallel current carrying conductors, torque affecting a current loop in a stable magnetic field.
4. Magnetic Flux, Faraday’s Law and Lenz’s Law: Magnetic flux, Gauss’s law in magnetism, Faraday’s induction law, motional emf (electromotive force), Lenz’s law.

C. Applied Techniques and Instructional Studies

General Physics II course is composed of four lectures of 45 minutes and two laboratory sessions of 45 minutes weekly. Principal information on the topics is given in the first two lectures named as learning session. During the following two lectures, problem solving activities are carried out as an exercise of the principal, called as exercise session. During the laboratory part, experiments concerned with the learned topics are conducted, named as laboratory session.

Learning session in experimental group is comprised of "Ask Together Learn Together" technique proposed by Aç kgöz [26] and "Jigsaw" technique developed by Aranson *et al.* in early 1970's [27, 28]. During the exercise session, problem solving instructional study in cooperated groups was used. In laboratory session, parallel to the studied topics, problem experiment instructional study in cooperated groups was used. Which cooperative learning techniques and cooperative instructional studies were used in which topics are given in Appendix B.

In learning session of control group, conventional teaching method including lecturing and discussion/question-answer techniques was applied. At exercise session, the problems solved in the experimental group along with similar additional problems were solved on the board. In the laboratory session, deduction experimental method, at which experimental process is fully oriented, was applied.

D. Used Instructional Materials

Experimental group

In the learning sessions of the course, at which "Ask Together Learn Together" technique was used, "reading passages", "question cards" on that the students can write individual questions and "question-answer cards" on that the students can write group questions and answers, were used. In "jigsaw" technique, "reading passages" at which the topics were divided according to specialty fields were used. In preparation of reading passages, the concepts were tried to be explained in a comprehendible way. Physical meaning of the relations and important points were stressed and the students were allowed to focus on these points. In addition, with the selected writing type, shape and highlights, a course that would not bore the students was proposed. Taking into account the time that the students would use in their studies on reading, the main principals and concepts were underlined without excessive details.

"Problem sheet" that includes the problems to be solved and the "problem solution sheet" that includes problem solving stages were used in the exercise sessions. Some of the questions were selected from text books and some of them were prepared by the researchers. Common results of the studies of Bagno and Eylon [21], Monica, Hessler and De Jong [29] and Van Weeren, De Mul, Peters, Kramers-Pals and Roossink [30] indicate that following a certain solution process such as analyzing problem, keeping key relationships (relation and principals that should be used in solution), planning how to make the solution and making solution improves students' problem solving skills, allows them to decide how to structure knowledge at solution stage and increases their success. Therefore, in problem solution sheets following stages were determined; a) summarizing problem b) writing given data, c) writing asked data, d) writing physical principals, rules and relations to be used in solution e) drawing necessary diagrams for solution f) solution of problem g) reviewing solution and h) interpreting conclusion.

In laboratory sessions, "problem experiment sheet" that includes the experiment to be carried out and "problem experiment solution sheet" were used. In their study, Heuvelen, Allen and Mihas [31] mentioned about experimental problem solving method, one of the methods that would let students to learn the topics. As far as these researchers convey, each problem introduced in this method includes one problem sentence and design of experimental tools necessary for the solution. In solution of experimental problems, students follow this procedure: defining introduced problem, dividing problem into sub steps, deciding on collection of data to be used in solution of each sub steps, suggesting necessary approach and estimations, preparing experimental setup. These researchers also expressed that this method can be effective in teaching. In our research, it was aimed to form a structure allowing students to organize their experiments and carrying them out by following the above mentioned steps in problem experiment sheets. Experimental processes were given with problem situations in this structure. In addition, tools and devices to be used in the experiments were introduced with their names and figures on the sheets. It was considered that diagram expression of experimental setup would limit discussions of students regarding the experiment. Hence, in problem experiment sheets, an arrangement of experimental setup was not included. In order to follow the above mentioned processes, a problem experiment solving sheet was prepared for students. On the solution sheets, solution estimations of students regarding problem situation and comparison of their estimations with the results obtained from the experiments can be recorded.

Control group

In learning sessions, the students followed the course from a text book widely used in our country [32].

In exercise sessions, problem sheets employed in the experimental group together with some additional problems from the course book were used.

At laboratory sessions an experimental booklet, that shows the experimental setup and stages, how to do necessary measurements, the items to be calculated and the graphics to be drawn, was used.

V. IMPLEMENTING TEACHING SEQUENCE IN THE CLASSROOM

The application was carried out by the same researchers for a period of four weeks at each group. The stages indicating application processes of techniques and instructional studies that were used in learning, exercise and laboratory sessions in both groups are given below.

A. Experimental Group

Learning session:

"Ask together learn together" technique application process includes following activities:

1) Circulating Reading Passages (Approximate duration 3 min.): Each student was given a reading passage.

2) Individual Studying on Reading Passage and Preparation of an Individual Question (Approximate duration 30 min.): In this stage, students studied on reading passages and prepared their individual questions. While preparing individual question, the students were warned that the prepared questions would be evaluated. Therefore, rather than simple questions based on numerical solutions, the students were asked to produce questions for learning main concepts of the studied topic in the level of comprehension. At this process, the quality of each prepared individual question was evaluated. The evaluation was made out of 5 points.

3) Formation of Cooperated Groups Comprising Five Students (Approximate duration 5 min.): The groups were formed in a heterogenic style, taking achievement and social levels of students into account. For mission communion, summarizer, inspector, material supplier and writer tasks were assigned to students in the groups and they were asked give a group name.

4) Group Discussion and Preparation of Group Question (Approximate duration 10 min.): Evaluating individual questions and discussing on these, each group formed a group question. Then they wrote this question by defining groups name and members, on question section of question/answer card that was given to them. While preparing group questions, the students were also warned that the prepared questions would be evaluated. At this process, the quality of prepared group question was evaluated. The evaluation was made out of 10 points.

5) Swapping Group Questions (Approximate duration 2 min.): Material supplier of each group took their question cards to another group.

6) Answering the Received Questions by the Groups (Approximate duration 10 min.): Discussing the questions that they received, the groups prepared answers and wrote these on answer section of question/answer card, also including group and member names.

7) Presentation of Answers in the Class and Discussion (Approximate duration 30 min.): Summarizer of each group presented the question and their answer to the class. After presentation of each group, class discussion was made for completing the missing and non-clear parts.

At last three processes, the answers that the groups gave to the questions they received and the presentation of the answer was evaluated. The evaluation was made out of 15 points.

"Jigsaw" technique application process includes following activities:

1) Formation of Jigsaw Groups (Approximate duration 3 min.): Due to the fact that the topics on which this technique is applied can be divided into two, jigsaw groups included two students. Before forming the groups, the researcher warned the students that number 1 students should know to which students number 2 was given after him and similarly, number 2 students should follow the students to which number 1 was given before them. At this stage, the students were given number 1 and number 2 at random. It was stated that, in jigsaw group, the students who was given number 1 will study with the students number 2. Thus, jigsaw groups were formed at random and mixed style.

2) Formation of Specialist Groups (Approximate duration 5 min.): With the formation of jigsaw groups, 25 students who would study one part of the topic were given number 1; and 25 students who would study the other section were given number 2. By dividing these groups of 25, into haphazard groups of 5, specialty groups were formed.

3) Studying Given Specialty Topics by Specialist Groups (Approximate duration 40 min.): The study over reading passage was carried out by specialty groups. For learning this material and for determining how to explain it to their friends in jigsaw group, the students made discussions.

4) Disintegration of Specialty Groups and Formation of Jigsaw Groups (Approximate duration 2 min.): At this stage the students were separated into specialty groups and formed jigsaw groups determined at the beginning of the course.

5) Explaining the Specialty Topics (Approximate duration 40 min.): The students explained their specialty topic to each other in jigsaw groups.

Assessment was not made in learning sessions which used jigsaw technique.

Class organizations used in the learning sessions of the experimental group are shown in Figure 1.

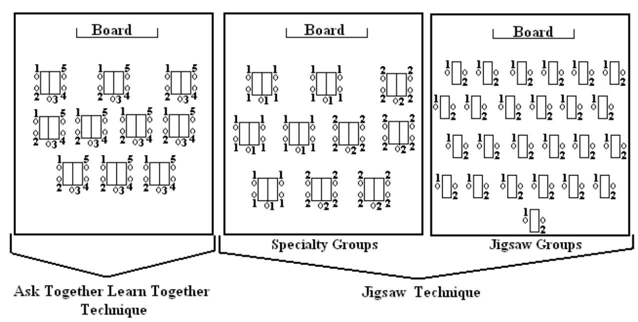

FIGURE 1. "Ask Together Learn Together" and "Jigsaw" techniques class organization.

Exercise session:

Problem solving instructional study in cooperated groups applying process includes following activities:

1) Formation of Cooperated Problem Solving Groups (Approximate duration 3 min.): The groups formed at this stage were the same groups formed in learning session.

2) Distribution of Problem Sheets and Problem Solution Sheets (Approximate duration 2 min.): Each group was given a problem sheet including the same problems and problem solution sheets equal to the number of questions.

3) Solution of Problems in Groups by Themselves (Approximate duration 50 min. and for each question approximately 10 min.): Students in the group reaches to the solution by discussing among each other and following the steps in solution sheets. The solution of each question was made on a separate problem solving sheet. At this stage, as the group or student who would solve the question was not certain, the students were warned that the solution should be understood by all individuals in the group and the problems should be solved according to the process. The answers that the groups gave to the problems according to stages in problem sheet were evaluated out of 20 points.

4) Solution of Problems in front of the Class by Group Representative (Approximate duration 35 min.): As the number of problems to be solved were lower than number of groups, all groups were not able to solve problems. Therefore, the groups allotted by researcher for solving each problem. At the same time, the students who would solve the problem in the group was determined at random such as first letter of his/her name, surname and date of birth (the one whose first letter of his/her name came first in the alphabet or the one whose date of birth came first.) the students selected in the determined group presented the solution of the question on the board. At this stage, the student who solved the problem made the presentation without looking at the solution on the solution sheet that they have prepared. The solution of group member was evaluated out of 10 points. The points, that is given accuracy and wrong of the solution was added to or deducted from 20 points that was given in the first evaluation.

Laboratory session:

Problem experiment instructional study in cooperated groups application process includes following activities:

1) Formation of Cooperated Experiment Groups (Approximate duration 3 min.): The groups formed at this stage were groups of five formed in learning session.

2) Distribution of Problem Experiment Sheet and Solution Sheet (Approximate duration 2 min.): Each group was given a problem experiment sheet including the same experiment and a problem experiment solution sheet.

3) Discussion, Experimentation and Filling Experiment Solution Sheet (Approximate duration 70 min.): At this stage, the first study of students included discussing problem situations in the group and to record theoretical explanations that they produced to problem experiment solution sheet. After that, with the aim of testing the ideas that they produced and they arranged experimental steps. For realizing theoretical explanations on which they defined experimental measurements the students made this over their own decisions. Again, the measurements and observations were recorded on problem solution sheet. Later, the students compared experimental results with theoretical explanations, discussed on it and defined the solution that they reached on experiment solution sheet.

At the end of the application, the experimental study and results and explanations in experiment solution sheet were evaluated over 30 points.

4) Individual Examination of Students at the end of the Topic (Approximate duration 15 min.): This stage is carried out after completing laboratory session each student is given an end-topic scan sheet including questions with short answers, for underlining main concepts and principles regarding the learned topics. The students answer these questions on these sheets. The evaluation was made according to answers that the students gave. For the topics where "ask together learn together" method was used, the evaluation was made over 20 points and for topics where "jigsaw" technique was used, the evaluation was made over 50 points.

The assessments made in applied sessions were added to the final term achievement marks of students in this group. However, the data concerning those assessments were not included in this study.

At all application stages, the researcher undertaking teacher's role keeps in touch with the groups to answer unresolved points and controls whether the activities are carried out in line with the mentioned processes or not.

B. Control Group

Learning session:

The topics at learning session and the examples about the topics were explained by the researcher in control group. At that stage, the students participated in the courses by taking notes about the topics, listening and asking questions sometimes. The class organization in learning session of this group is given in Figure 2.

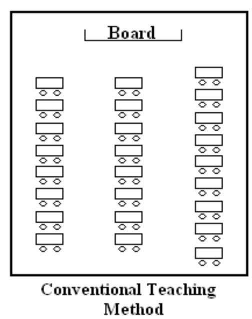

FIGURE 2. Conventional teaching method class organization.

Exercise sessions:

Before the exercise session starts, the students were asked to get ready for the problems. The problems were then solved on the board by the teacher and by the students who wanted to solve. In solving the problems, a pre-determined problem solving process was not used. During the solution, necessary figures were drawn for comprehending the solution, given and asked items were written down on the board.

Laboratory sessions:

At laboratory session in this group, the students performed the experiments within the groups. However, this group study does not have a cooperative learning character. The students chose their partners with their free wishes. The experiments were carried out by the use of prepared instructions and pre-formed ready setups. During the experiments, the students only carried out desired measurements and applications.

VI. FINDINGS

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

A. MTAS Findings

At the end of the experimental study, for determining whether there was an improvement in academic achievement for experimental and control group students, post-test and pre-test datum were evaluated using paired samples t-test as shown in the Table II.

TABLE II. t-test data indicating the relations between pre-test/post-test MTAS achievement scores of experimental and control group students.

Test/Groups	n	Mean	Standard Deviation	t	p	Significance Level
Pre-test / Experimental Group	50	5,02	2,63	-14,065	0,000	p < 0,05 significant
Post-test / Experimental Group	50	12,74	3,98			
Pre-test / Control Group	50	4,98	2,23	-6,352	0,000	p < 0,05 significant
Post-test / Control Group	50	8,36	3,04			

According to the data given in Table II, it is found that there is a significant difference between pre-test and post-test 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 independent samples t-test as shown in the Table III.

TABLE III. t-test data indicating relation between post-test MTAS achievement scores of experimental and control group students.

Groups	n	Mean	Standard Deviation	t	p	Significance Level
Experimental Group	50	12,74	3,98	6,189	0,000	p < 0,05 significant
Control Group	50	8,36	3,04			

According to the Table III, at the end of the application, it is found that there is a significant difference for experimental group students between post-test achievement score averages of experimental and control group students obtained from the scale.

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

After certain period of time when the topics were learned, for determining whether there was a difference between academic achievement for both group of students, the student achievement scores obtained from delayed-test were evaluated using independent samples t-test as shown in the Table IV.

TABLE IV. t-test data indicating relation between delayed-test MTAS achievement scores of experimental and control group students.

Groups	n	Mean	Standard Deviation	t	p	Significance Level
Experimental Group	50	12,60	3,74	9,543	0,000	p < 0,05 significant
Control Group	50	6,70	2,26			

According to the data in Table IV, it is found that there is a significant difference between delayed-test achievement score averages of the experimental and control group students. This difference is again in favor of the experimental group students.

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, paired-samples t-test was used as shown in the Table V.

TABLE V. t-test data indicating relation between post-test/delayed-test MTAS achievement scores of experimental and control group students.

Test/Groups	n	Mean	Standard Deviation	t	p	Significance Level
Post-test / Experimental Group	50	12,74	3,98	0,229	0,819	p > 0,05 not significant
Delayed-test / Experimental Group	50	12,60	3,74			
Post-test / Control Group	50	8,36	3,04	3,200	0,002	p < 0,05 significant
Delayed-test / Control Group	50	6,70	2,26			

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 experimental groups students. However, between average post-test achievement scores and average delayed-test achievement scores of control group students, there is a statistically significant difference for post-test achievement scores in terms of the same significance level.

B. Ideas of Students

Findings obtained from written ideas of both group of students regarding the overall application are as follows:

Views of experimental group

a) When the ideas of students are evaluated regarding the effects of cooperative learning on their learning, it is found that this method;
i) taught them to learn the topic during the actual course,
ii) created an atmosphere to learn topics in the course for the students who are not willing to study,
iii) maintained them to learn and made their learning easier,
iv) made topics more comprehendible and easier,
v) was an effective, interesting and motivating method that made them active,
vi) prepared a discussion environment and teaching topics to each other provided a better learning,
vii) thought them how to solve problems with problem solving activities that were prepared according to cooperative learning techniques, so they do not memorize the solution,
viii) organized experimental activities designed in accordance with cooperative learning techniques, rather than carrying out the experiments over ready set ups supported the course. The students stressed that they had opportunity of producing by discussion and comparing.

b) Relating the effects of cooperative learning on providing permanence in their learning the students convey that the method;
i) is not based on memorizing,
ii) provided learning of the topics without need to be rehearsed as they were always active
iii) provided them to remember the knowledge they learned in a meaningful way,

c) Ideas of students about the effects of cooperative learning on making the course entertaining and participating the course indicate that;
i) the applied method made the course entertaining and enjoyable,
ii) as they learned more things their attendance increased and it made them ambitious and more interested,
iii) as they saw that they were able to solve the questions easier and they were able to lecture their friends about the topics, they participated in the courses in a more active way.

d) Relating the effects of cooperative learning on their social development, it is found that;
i) they had the change to immediately ask any question they wondered,
ii) they were in contact with the teacher more than they thought,
iii) they interacted with their friends in a better way with the help of group study,
iv) everyone conveyed his/her ideas and to reach a common objective made them socialize,
v) their responsibility on their friends increased.

In addition to these ideas, the students in the experimental group expressed that;
i) the method was exhausting,
ii) group study should not be limited to classroom activities and should continue outside the courses,
ii) the materials provided were clear, comprehensible, sufficient informative and beneficial.

Views of control group

a) Relating the effects of conventional teaching on their learning, it is found that;
i) physics courses can not lead to sufficient learning by just lecturing,
ii) sufficient learning can only be achieved if the students get prepared for the course and then attend the class,
iii) they could only be able to learn the topics as much as they listen,
iv) the conventional method is not suitable for every single student and this method only eases teacher's job,
v) during the lecturing "what is learned by whom" is not clear.

b) Relating the effects of conventional method on permanence of their learning, it is found that;
i) the students could not even answer the questions they in already knew,
ii) the topics were based on memorization,
iii) memorizing and remembering relations was difficult and therefore they were forgotten when the students did not frequently rehearse,
v) as the topics were studied in an abstract way they forget them after a short time

c) Concerning the effects of conventional method on making the course entertaining and participating the course, it is found that;
i) the students were bored after a certain time of listening,
ii) their attention was disturbed and at the end of the course they had concentration problem,
iii) this method made them passive and therefore during the course full participation was never achieved.

d) Concerning the effects of this method on their social development, it is found that the students were not able immediately to ask an unclear topic to the teacher. These students have no idea on interaction with their friends.
In addition to all these, these students underlined that;
i) achievement of the method depends on the teacher and lecturing style of the teacher,
ii) this method is not suitable for university level,
iii) the book which is used in the course explained some topics in a complicated way and they were not able to comprehend certain topics.

VII. DISCUSSION AND IMPLICATIONS

This part of the paper focuses on interpreting and discussing fundamental outcomes of the research and implications.

Firstly, a significant difference has been detected between pre-test and post-test achievement scores for both groups of students. The differences are in favor of post-test scores indicating that at the end of the teaching, there is an improvement in academic achievement of the students of both groups. However, when the post-test achievement scores of both groups were compared, it is found that experimental group students taught by cooperative learning techniques are more successful than control group students. At this point, it is found that cooperative learning increased magnetism topics academic achievement of students to a higher level when compared to conventional teaching method. This result obtained for magnetism topics is in agreement with the results of other studies [4, 9, 10, 11, 14, 15, 16]. After analyzing the effects of cooperative learning on retention level of the knowledge, while no significant change is observed in knowledge of experimental group, it is found that there is a significant regression in knowledge of control group students. This suggests that cooperative learning is more effective in remembering learned knowledge than conventional method.

Based on ideas of students, it can be noted that cooperative learning provides a better learning environment with discussions while learning magnetism topics and helps students to learn in an easily, effective and meaningful way. Other studies concerned with cooperative learning also support these results [33, 34, 35]. Interaction of students with each other when solving problems, deciding on a solution by discussing with each other and evaluating different views provide them a better understanding atmosphere as pointed out by other studies [35, 36, 37]. Similar effects appear in conducting experiments in cooperated groups and learned information is not immediately forgotten indicating the effectiveness of this method.

In both learning and exercise sessions, passiveness in control group turns the students into passive listeners and after a short time they begin to lose concentration from the course with their distracted attentions. In laboratory sessions, students perform experiments without fully thinking on it and making any comments. It is thought that this situation causes the students not to learn and realize what they have learned. Therefore, students in this case chose to memorize rather than trying to understand.

Our experiences during the application show that despite the unwillingness of control group students, experimental group students spend greater efforts and enjoyed the application very much. This experience of them also influenced their ideas about having an entertaining course and having higher course participation. It is clear that, these techniques that were applied in experimental group made the physics course, to which non-science students attended with unwillingness, entertaining and enjoyable as mentioned in other studies regarding cooperative learning [3, 11, 34, 38] and increased the interest of the students to the topic thus provided a higher participation.

Experimental group students noted that this method made the sequence very tiring. Even if it seems like a negative criticism made by the students, it is evaluated as a positive and beneficial situation by the researchers. This shows that the method forces students to study more and gains an effective studying habit.

The ideas of students suggested that cooperative learning techniques improve social abilities of the students. As Nattiv, Winitzky and Dricky [39] express in their research, students are engaged in a higher rate of interaction with their friends when cooperative learning techniques used. Similar improvement is observed in the interaction between teacher and students, this situation also results in improvement of interpersonal communication skills [16]. In addition, it is thought that the students have undertaken the responsibility of other members in cooperative groups and attachment of importance to the ideas of others improved their responsibility and democracy understanding.

Improvement on social development together with responsibility and democracy understanding indicate that these techniques can be suitable in achieving affective objectives. Achieving affective objectives is one of the most important deficiencies and it is assumed that a sufficient environment for affective development cannot be provided with conventional teaching.

Considering the selected teaching materials, the ideas of students indicate that these materials should be prepared as appropriate as possible to their levels also clear and comprehensible. Even though the use of course books are widespread, sometimes course books may not be convenient to the level of students. In their study, Bagno and Eylon [21] noted that some deficiencies in content and organization of course books may cause a difficulty in learning related topics. It is therefore important to compile various sources and organize topics, on which students have problems, at a level that students can easily understand. This should be paid attention especially in activities where the students learn by themselves. Boxtel *et al*. [4] suggest that using course books results in a negative effect on students' interaction in terms of detailed studying and raising views in cooperative learning. The researchers also underline that students sometimes waste time while analyzing the course books and this prevents them communicating to each other and discuss.

The other important point of this work is carrying out this study in an education faculty. The teacher candidates are introduced different techniques and learned by their own experience. During the application, it is observed that some students found the method beneficial and noted that they would use cooperative learning in the future on-service. Therefore, it is clearly understood that introducing such methods to science and physics teacher candidates helps them in their professional life.

In application stage, for preventing experimental study influenced by undesired variables, the reading passages used in experimental group were handed to the students at the beginning of learning sessions. However, the students noted that receiving reading passages before the beginning of the sessions would be more beneficial. Therefore, it is suggested that giving reading passages before they attended the course would pave the way for teacher and students.

The other point students underlined is that assigning project works outside the school and providing cooperation to realize this can be achieved to a higher efficiency level.

Prior to experimental study, the materials and techniques were applied as a pilot study to similar students who received education in the same department and arrangements regarding the deficient parts were rearranged according to reactions and results. It is thought that, this pre-application work increased the achievement of the experimental study. Hence, it is strongly recommended to appliers to use these techniques continuingly for reaching to the best results.

In addition, in teaching of magnetism topics the use of other effective teaching methods and techniques and comparing their results with present ones can indicate how to teach these topics in the most effective way. Accordingly, the magnetism topics can be among the interesting topics, rather than the topics that the students dread.

Another point which was not directly dealt with in the study is the analyzing the effects of laboratory studies carried out by cooperative learning activities on psychomotor development of students. It is thought that, the experiments that the students carry out by designing the related tools and devices themselves can improve their skills. The researchers at this point suggest that further research ought to be carried out on improving psychomotor objectives through the cooperative learning and this would greatly contribute to teaching physics.

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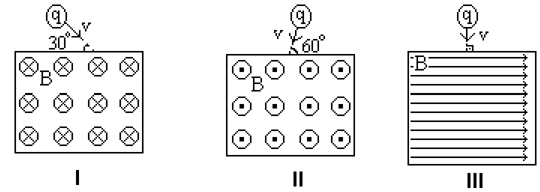
APPEND X A. Sample questions of MTAS

Sample question for level of comprehension:



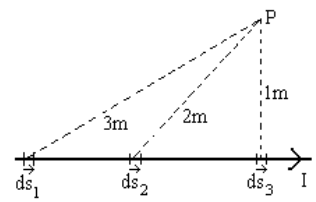
A charged particle (q) enters the magnetic field regions with a constant velocity $\vec{V}$ as shown in situations I, II and III. The magnitudes of the magnetic forces the fields exert on this charge are defined as F_1, F_2 and F_3 respectively. Which of the following is correct for the magnitudes of the forces?

A) $F_1 = F_2 = F_3$ B) $F_1 > F_2 > F_3$ C) $F_2 > F_1 > F_3$

D) $F_3 > F_1 > F_2$ E) $F_3 > F_2 > F_1$

Sample questions for level of application of concepts:

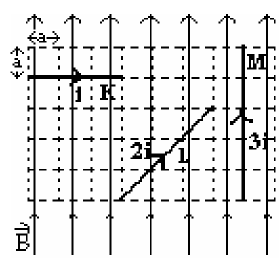
S.Q.1



As shown in the figure above, $d\vec{s}_1, d\vec{s}_2$ and $d\vec{s}_3$ are current elements on a wire which caries a steady current of I ($|d\vec{s}_1| = |d\vec{s}_2| = |d\vec{s}_3| = dx$). Magnitudes of magnetic flux densities which generated by these elements at point P are defined as dB_1, dB_2 and dB_3 respectively. Which of the following is correct for the magnitudes of the magnetic flux densities?

A) $dB_1 \rangle dB_2 \rangle dB_3$ B) $dB_2 \rangle dB_3 \rangle dB_1$ C) $dB_3 \rangle dB_1 \rangle dB_2$
D) $dB_3 \rangle dB_2 \rangle dB_1$ E) $dB_1 = dB_2 = dB_3$

S.Q.2



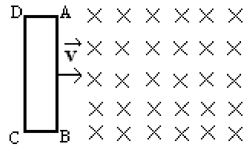
Only K, L and M sides of loop of wires are placed in a uniform and constant magnetic field of $\vec{B}$ as shown in figure. These wires carry steady currents of I, 2I and 3I respectively. Which of the following is correct for the magnitudes of the magnetic forces on the sides of K, L and M of the wires?

A) $F_K = F_L = F_M$ B) $F_K > F_L > F_M$ C) $F_M > F_L > F_K$

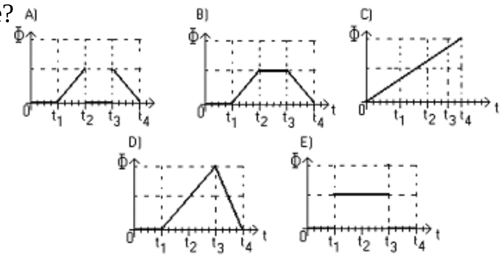
D) $F_L > F_K > F_M$ E) $F_L > F_M > F_K$

Sample questions for level of analyzing and evaluation of magnetism problems

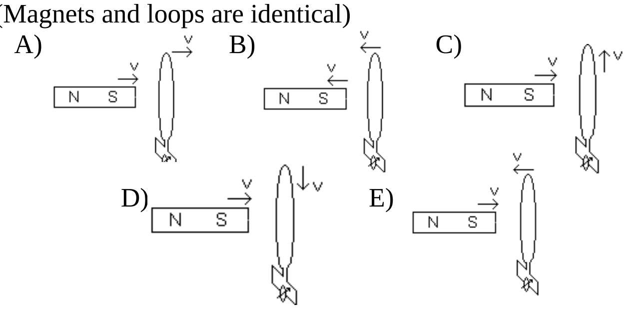
S.Q.1



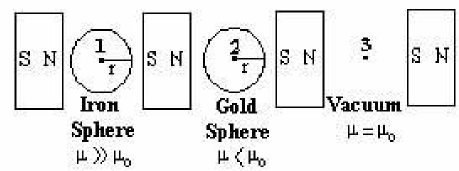
A rectangular loop, starting from the rest (t = 0) and moving with a constant velocity $\vec{V}$ towards a magnetic field region directed into the page. AB side of the rectangular enters to the field region at $t=t_1$ and CD side enters at $t=t_2$. These sides left from the region at $t=t_3$ and $t=t_4$ respectively. Which of the followings indicate magnetic flux through the loop as a function of the time?



S.Q.2. In which choice ammeter on the curricular loop shows the biggest magnitude of induced current? (Magnets and loops are identical)



S.Q.3. A system consisting of four identical magnets and two different spheres is set as shown in the figure. Which of the following is correct for the magnitude of the magnetic flux densities at the points of 1, 2 and 3? (Here, μ is the magnetic permeability of the spheres and μ_0 is the magnetic permeability of the free-space)



A) Magnitudes of the magnetic flux densities are equal at all three points because the magnets are identical.

B) Magnitude of magnetic flux density reaches its highest value at the point 3 because there is no medium which would affect the magnetic flux density in any way.

C) Magnitude of magnetic flux density reaches its highest value at the point 2 because gold is a better conductor than iron and it allows the field lines to penetrate better than iron.

D) Magnitude of magnetic flux density has its highest value at the point 1 because magnetization inside the iron sphere increases the magnitude of the magnetic flux density in the region including the point 1.

E) Magnetic flux densities have the same values at the points 1 and 2 and also they are higher than the one at point 3. Because, gold and iron are metals and same effects occur on the field lines for each case.

APPENDIX B. Cooperative Learning Techniques Used in Experimental Group and Instructional Studies

Week	Topic	Sessions	Applied Technique	Main Instructional Studies
1. week	Formation of Magnetic Field and Magnetic Features of Materials	Learning Session (90 min)	Ask together learn together	Reading, producing questions, sharing ideas, interviewing, asking for help, note taking, writing, answering questions.
		Exercise Session (90 min)	Problem solving in cooperated groups	Studying work-sheets, problem solving, finding key ideas, producing results.
		Laboratory Session (90min)	Problem experiment in cooperated groups	Experimentation, application in real life, sample event analysis, finding reasons, formulizing, finding cause-effect relationships, comparing.
2. week	Magnetic Field Sources	Learning Session (90 min)	Jigsaw	Reading, note taking, sharing ideas, interviewing, asking for help, writing, empathy with teacher, teaching someone, explaining, summarizing, giving example, answering questions.
		Exercise Session (90 min)	Problem solving in cooperated groups	Studying work-sheets, problem solving, finding key ideas, producing results.
		Laboratory Session (90min)	Problem experiment in cooperated groups	Experimentation, application in real life, sample event analysis, finding reasons, formulizing, finding cause-effect relationships, comparing.
3. week	Magnetic Force	Learning Session (90 min)	Ask together learn together	Reading, producing questions, sharing ideas, interviewing, asking for help, note taking, writing, answering questions
		Exercise Session (90 min)	Problem solving in cooperated groups	Studying work-sheets, problem solving, finding key ideas, producing results.
		Laboratory Session (90min)	Problem experiment in cooperated groups	Experimentation, application in real life, sample event analysis, finding reasons, formulizing, finding cause-effect relationships, comparing.
4. week	Magnetic Flux, Faraday's Law and Lenz's Law	Learning Session (90 min)	Jigsaw	Reading, note taking, sharing ideas, interviewing, asking for help, writing, empathy with teacher, teaching someone, explaining, summarizing, giving example, answering questions.
		Exercise Session (90 min)	Problem solving in cooperated groups	Work-sheets, problem solving, finding key ideas, producing results.
		Laboratory Session (90min)	Problem experiment in cooperated groups	Experimentation, application in real life, sample event analysis, finding reasons, formulizing, finding cause-effect relationships, comparing.