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EFFECTS OF PROBLEM-SOLVING STRATEGIES TEACHING ON THE PROBLEM-SOLVING ATTITUDES OF COOPERATIVE LEARNING GROUPS IN PHYSICS EDUCATION[1]

FİZİK EĞİTİMİNDE İŞBİRLİKLİ ÖĞRENME GRUPLARINDA PROBLEM ÇÖZME STRATEJİLERİ ÖĞRETİMİNİN PROBLEM ÇÖZMEYE YÖNELİK TUTUM ÜZERİNDEKİ ETKİLERİ

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ABSTRACT

In this research, the effects of teaching cooperative problem solving strategies on physics students' achievement, strategy levels, and problem solving attitudes were investigated. In this research, experimental procedures were carried out on second year upper secondary school students who attended a lower socio-economic status secondary school in the fall semester of 2005-2006 academic year in İzmir, Turkey. In this study, the pretest-posttest research model with control group was used. The research was performed on two groups. One group was the experimental group and the other was the control group. Research data were collected by means of a Physics Achievement Test, Scale of Problem-Solving Strategies, Scale of Problem-Solving Attitude, and problem solving sheets. During this study, cooperative problem-solving strategies were used with the experimental group (the strategy teaching group) and the control group was instructed with traditional teaching methods. In conclusion, it was found that the average of the strategy teaching groups' achievement, attitude and problem solving was much higher than control groups' achievement.

Keywords: Problem Solving Strategies, Cooperative Learning, Attitude, Physics Education

ÖZ

Bu araştırmada, işbirlikli problem çözme stratejileri öğretiminin, öğrencilerin fizik başarısı, strateji düzeyleri ve problem çözmeye yönelik tutumları üzerindeki etkilerinin ortaya çıkarılması amaçlanmaktadır. Denel işlemler, 2005-2006 eğitim-öğretim yılı güz yarıyılında İzmir ili sınırları içinde, alt sosyo-ekonomik düzeyde bulunan bir ortaöğretimin 10. sınıf öğrencileri üzerinde yürütülmüştür. Katılımcılar çalışmaya gönüllü olarak katılan öğretmenlerin sınıfları arasından seçilmiştir. Araştırmada kontrol gruplu ön test-son test araştırma modeli kullanılmıştır. Araştırma bir deney ve bir kontrol grubu olmak üzere iki grup üzerinde yürütülmüştür. Araştırmanın verileri, Fizik Başarı Testi (Hareket-Dinamik), Fizik Dersine Yönelik Problem Çözme Stratejileri Ölçeği, Fizik Dersine Yönelik Problem Çözme Tutum Ölçeği ve problem çözme yaprakları ile toplanmıştır. Araştırma sırasında, strateji öğretimi grubuna işbirlikli gruplarda problem çözme stratejileri öğretimi yapılırken kontrol grubuna ise geleneksel öğretim yöntemleri ile problem çözme stratejileri verilmiştir. Araştırma sonucunda, strateji öğretimi grubunun başarı, tutum ve problem çözme stratejileri ortalamasının kontrol grubuna göre daha yüksek olduğu bulunmuştur.

Anahtar Sözcükler: Problem Çözme Stratejileri, İşbirlikli Öğrenme, Tutum, Fizik Eğitimi

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INTRODUCTION

Physics is a natural science which investigates matter, energy and interaction of matter (Ertaş, 1993). We receive assistance from physics in daily life by using the tools used in science and technical areas, the structure of matter, and unknown aspects of the universe. Physics comes first in everything that is going on around us. The findings and research methods which have been determined for the last two centuries by physics have been so successful that other fundamental and applied sciences have used this knowledge (Ertaş, 1993).

Nowadays, when technology is taught, physics is the first thing comes to mind. Although physics is around us everywhere and makes our lives easier from the technological aspect, physics has not been taught very efficiently. The research done either in this country or abroad has found the same failure (Halloun and Hestenes, 1987; Van Heuvelen, 1991). Research done abroad has showed that conventional teaching has negative effects on most of the students. Even in well-developed countries, it has been discovered that goals cannot be reached in the teaching of science (Dieck, 1997; Rivard and Straw, 2000), that achievement in science is lower than other fields (Mattern and Schau, 2002), that students do not like science lectures (Neathery, 1991), and that most of them do not prefer the science area (Boylan, 1996). Regarding the situation in Turkey, it can be said that most students have a negative attitude towards science lectures, especially physics, during their education (Gök and Sılay 2005).

Several teaching methods can be used in physics teaching, according to the subject's content. Problem solving is one of them. Problem-solving is to know what to do in the situation of not knowing what to do. Problem-solving is not only finding the correct answer but also is an action which covers a wide mental period and abilities (Altun, 2002).

Problems are divided into two groups, routine and non-routine problems. Routine problems are frequently included in physics textbooks and known as the four arithmetic operations. It is called a word problem or story problem. The main goals of the four arithmetic operation problems are to improve the operations skills of the students in daily life, to teach the application of mathematical equations for problem, to explain thoughts by graphical methods, to make students understand both written and visual publications, and to gain the basic skills needed for solving problems. The purpose of the non-routine problems is to organize data, to classify them, to address the relationships, and to do several activities step by step.

Problem-solving strategies can be applied for the solution of both routine and non-routine problems. What are the effective factors in selecting strategies? Why are some strategies used more often? Can selection of strategies and applications be taught? Several arguments were done by the researchers in response to these questions. The problem-solving strategies

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found after an investigation of the literature (Altun, 2002; Dhillon, 1998; Hatfield, Edward and Bitter 1997; İsrael, 2003; Sarıtaş, 2002) are: to make a list systematically, to guess and control strategy, to plot a diagram, to find a formula, to use parameters, to work backward, to eliminate, to tabulate, etc.

When students come across a problem, generally they try to remember a rule to solve the problem. But this is not a good strategy, because there is no rule but a system. Teaching problem-solving strategies does not guarantee the learning of these strategies. Students should realize what and why they are doing and know the strengths of the strategies, in order to understand the strategies completely and be able to select appropriate strategies (Israel, 2003).

Numerous teaching methods can be used for problem-solving strategies. One of them is cooperative learning. Cooperative learning is studying for the same goal in small groups by helping each other (Açıkgöz, 2003). Individual study or coming up with an idea is not important in cooperative learning groups. The most important thing is to come up with an idea by interacting with each other. Various techniques of cooperative learning (Learning Together, Academic Conflict, etc.) can be used to build an idea. Therefore, it is thought that the usage of problem-solving strategies is more useful than conventional methods for cooperative learning. It is more convenient because of more outputs and periods than other methods; creating an effective place to produce an output which improves abilities of leadership, sharing, criticizing; not needing any other organization or spending, and the individualizing of teaching.

The importance of problem-solving in physics education cannot be denied. Therefore, the investigation of student's attitudes and behaviors while solving a problem becomes important.

Attitude can be defined as the tendency to give learned, consistent, positive or negative reaction to an object (Fishbein and Ajzen, 1975). Attitude is a tendency for individuals who organize thoughts, emotions and behaviors towards a psychological object (Kağıtcıbaşı, 2004).

An individual should have new experiences and information to change their attitude toward an object. However, every change does not lead to a change in attitude. After all, these new experiences should change the beliefs of the individual. Also this is caused by realizing the information at the base of these beliefs (Ajzen and Fishbein 2000).

Human beings are not born with attitudes, they learn them afterwards. But how do they have attitudes for a specific subject, object, or people? This question does not have a single answer. Some attitudes are based on own experiences, some are gained from other sources. Attitudes are generally applied from direct experience, reinforcement, imitation, or social learning. However, the attitude does not stay the same and it changes in the course of time. This attitude cannot be measured directly, but it can be detected by indirect behavior. The behavior used in that measurement is generally social behavior, determined as giving a response or an opinion (Kağıtcıbaşı, 2004).

In this study, the effects of the teaching of cooperative problem-solving strategies, physics achievement of student, level of strategy, and attitudes toward problem-solving were investigated.

METHODOLOGY

Experimental procedures were performed in the fall semester of 2005-2006 academic year in Izmir on 10th grade students who are accepted as being lower social-status. The attendees were selected from the classes of volunteer teachers. In this study, there were 25 and 21 students for the strategy teaching and control groups, respectively.

Data Base Tools

The calculated reliability of the achievement test was found to be 0.92 by using the KR-20 formula. Also, the reliability of the Scale of Problem-Solving Strategies for Physics was calculated as 0.85. The scale is divided into four sub-factors, namely, Organization, Processing, Getting Assistance, and Memorization after evaluation. Other scaling studies based on Problem-Solving Attitude for Physics showed that the reliability was 0.87. The sub-factors were named as Attention and Fade-Phobia. These sub-factors were compared with the groups (strategy and control) included in the experimental design. Finally, the problem solving strategies of the students were observed by using problem solving worksheets.

Experimental Procedures

Experimental procedures were applied for High-School Physics II strategy and control groups on the scheduled time and day (3 days per week, 6 hours totally) for each week in the fall semester of 2005-2006 academic year. Both groups were taught in the same manner during the research. Pre-test and post-test research models were used. The research was applied on two groups, Experiment and Control groups.

The applications were covered with the borderlines below;

a) Prior to the study, the students were given a Physics Achievement test, Scale of Problem-Solving Strategies in Physics, Scale of Problem-Solving Attitudes in Physics, and then the studies were started.
b) Prior to teaching the planned chapters, the students were informed about being taught problem solving strategies and cooperative learning methods and techniques. The information period was completed in 4 weeks (24 hours).
c) During the experimental procedures, problem-solving strategies were explained by the cooperative learning method (Learning Together, Learning Assembly I-II, etc.) to the experiment group and by conventional learning method to the control group. Lectures were

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presented by conventional methods (Direct Speech, Discussion, etc.) to the control group as to the strategy group. The previous lecture was repeated briefly in the following lecture and the problem-solving strategies and activities were done during the rest of the lecture on the same problems solved by using the same solving strategies with both groups.

d) In the experimental period, students in both groups studied on the problem-solving worksheets prepared by the researcher.
e) During the experimental procedures, the students were not given practice problems and/or assignments.
f) The Physics Achievement Test, Scale of Problem-Solving Strategy for Physics, and Scale of Problem-Solving Attitude were applied to both groups after the experimental period was over and the final data were collected.

ANALYSIS

Effects of Strategy Teaching on Students' Achievement in Physics

The achievement of students in the experiment and control groups on physics was checked before the research to compare the effects of the strategy teaching. Therefore the arithmetic mean of the pre-scores and standard deviations of the Physics Achievement Test (PAT) were calculated and t-test was applied to check the difference between the averages of the groups to see if it was meaningful or not. Results can be seen on Table 3.1.

Table 3.1 PAT Pre-Scores of Strategy Teaching and Control Groups

Groups	n	$\bar{x}$	SD	df	t	p
STG	25	6.76	2.12	44	0.00	p>0.05
CG	21	6.76	2.44			

STG: Strategy Teaching Group; CG: Control Group

The achievement average of the strategy teaching and control groups was found the same, as can be observed in Table 3.1 These results showed that the physics achievement levels of both student groups were the same before the research. Then arithmetic means of the post-scores and standard deviations of the Physics Achievement Test (PAT) were calculated and t-test was applied to check the difference between the averages of the groups to see if it was meaningful or not. The results can be seen in Table 3.2.

Table 3.2 PAT Post-Scores of Strategy Teaching and Control Groups

Groups	n	$\bar{x}$	SD	df	t	p
STG	25	24.64	5.47	44	10.93	p<0.05
CG	21	10.42	2.54			

The achievement of the strategy group was found higher than the average of the control group, as can be observed from the results in Table 3.2. The calculated t value is higher than the standard t table value, therefore the difference between the achievement averages of groups is found to be an advantage for the strategy groups. These results are important from the statistical aspect (df=44, t(10.93)=2.02).

Effects of Strategy Teaching on Students' Strategy Use

The problem-solving strategies of students included in both groups were checked prior to the experimental procedure to assess the effect of strategy teaching on students' technique. The arithmetic mean of the students' pre-scores and standard deviations of the Problem-Solving Strategies Scale (PSSS) for Physics were calculated and t-test was applied to check the meaningful difference between averages of the groups. Results can be seen on Table 3.3.

Table 3.3 PSSS Pre-Scores of Strategy Teaching and Control Groups

Groups	n	$\bar{x}$	SD	df	t	p
STG	25	156.04	20.70	44	0.14	p>0.05
CG	21	156.95	20.88			

Calculated t value was found lower than standard t-value after the analysis results were compared, the difference between averages (df=44, t(0.14)=2.02) was ignored from the statistical aspect. The pre-scores of results for PSSS sub-factors are given on Table 3.4.

Table 3.4 Pre-Score Results of PSSS Sub-Factors for Strategy Teaching and Control Groups

Sub-Factors	Groups	n	$\bar{x}$	SD	df	t	p
Organization	STG	25	61.68	10.15	44	0.50	p>0.05
	CG	21	63.19	10.27			
Processing	STG	25	43.80	6.87	44	0.63	p>0.05
	CG	21	45.14	7.40			
Get Assistance	STG	25	29.84	4.48	44	0.40	p>0.05
	CG	21	29.28	4.91			
Memorization	STG	25	20.72	3.82	44	1.22	p>0.05
	CG	21	19.33	3.82			

The difference between the averages of the groups found from the results of sub-factors (Organization, Processing, Get Assistance and Memorization) showed that the strategy group was advantageous from the statistical aspect, as can be seen from the results on Table 3.4. After the experimental period, the arithmetic means and standard deviation of the scores taken from the scale by students were calculated to prove the strategy usage of the groups. t-test was applied to check the meaningful difference between the averages of groups and these results are presented in Table 3.5.

Table 3.5 PSSS Post-Scores of Strategy Teaching and Control Groups

Groups	n	$\bar{x}$	SD	df	t	p
STG	25	191.40	8.39	44	9.97	p<0.05
CG	21	157.47	14.35			

The strategy average of the strategy groups was found higher than the average of control groups, which can be observed on Table 3.5. When standard deviations were compared, the standard deviation of the control group was found remarkably higher than the standard deviation of the strategy teaching group. This result showed that the strategy teaching group was more homogeneous and the control group had more heterogeneous features. t-test was applied to check the meaningful difference between averages of the groups and calculated t value was found higher than the standard t table value, therefore this result showed that there was a meaningful difference between the groups (df=44, t(9.97)=2.02). The arithmetic mean and standard deviation of the groups were calculated according to sub-factors of the PSSS to find the meaningful difference between strategy averages of the groups. Also, t-test was applied and the results are shown on Table 3.6.

Table 3.6 PSSS Sub-Factors Post-Scores of Strategy Teaching and Control Groups

Sub-Factors	Groups	n	$\bar{x}$	SD	df	t	p
Organization	STG	25	76.20	4.64	44	7.54	p<0.05
	CG	21	63.09	7.05			
Processing	STG	25	54.64	3.60	44	7.05	p<0.05
	CG	21	44.47	6.03			
Get Assistance	STG	25	35.52	1.82	44	4.91	p<0.05
	CG	21	30.52	4.68			
Memorization	STG	25	25.04	1.88	44	8.63	p<0.05
	CG	21	19.38	2.55			

The difference between the averages of the groups was found to be advantageous for the strategy groups in the sub-factors of organization, processing, getting assistance, and memorization. This was important from the statistical aspect, as can be observed from the results on Table 3.6.

Effects of Strategy Teaching on Attitudes of Students towards Physics Problems

The Problem-Solving Attitude Scale for physics (PSAS) was applied to observe the effect of strategy teaching on the attitudes of students concerning physics problems. Arithmetic means of pre-scores and standard deviations of the scale were calculated. t-test was performed to check the meaningful difference between the average of the groups and the results are shown on Table 3.7.

Table 3.7 PSAS Pre-Scores of Strategy Teaching and Control Groups

Groups	n	$\bar{x}$	SD	df	t	p
STG	25	122.16	13.20	44	0.37	p>0.05
CG	21	123.85	17.17			

The attitude averages of the strategy teaching and control groups were found to be the same, as observed from the results on Table 3.7. t- test was applied to check the meaningful difference between averages of the groups. The difference between averages of the groups was ignored from the statistical aspect (df=44, t(0.37)=2.02). The meaningful averages between groups were sought according to the sub-factors of the PSAS. First of all, the arithmetic means of the sub-factor scores and standard deviations were calculated for both groups and then t- test was applied to check the difference between the averages of groups. These results are shown on Table 3.8.

Table 3.8 Pre-Score Results of PSAS Sub-Factors for Strategy Teaching and Control Groups

Sub-Factors	Groups	n	$\bar{x}$	SD	df	t	p
Attention	STG	25	77.44	11.70	44	0.70	p>0.05
	CG	21	79.52	7.45			
Fade-Phobia	STG	25	44.72	9.66	44	0.11	p>0.05
	CG	21	44.33	13.92			

The strategy average of the strategy teaching and control groups was found to be the same, as seen on Table 3.8. After t- test results were investigated, both sub-factors for PSAS were ignored from the statistical perspective. The post-scores of the students included in both groups were calculated and then t-test was applied to check the meaningful difference between averages of the groups. These results are shown on Table 3.9.

Table 3.9 PSAS Post-Scores of Strategy Teaching and Control Groups

Groups	n	$\bar{x}$	SD	df	t	p
STG	25	144.36	10.65	44	5.06	p<0.05
CG	21	125.90	14.04			

The attitude average of the strategy group was found higher than the average of the control group as can be observed from the results on Table 3.9. Furthermore, this result was found important from the statistical aspect (df=44, t(5.06)=2.02). The post-scores of the groups were calculated according to the sub-factors of the PSAS. t-test was applied to check the difference between averages of groups according to sub-factors, and these results are shown on Table 3.10.

Table 3.10 Post-Score Results of PSAS Sub-Factors for Strategy Teaching and Control Groups

Sub-Factors	Groups	N	$\bar{x}$	SS	sd	t	p
Attention	STG	25	86.20	4.83	44	4.41	$p<0.05$
	CG	21	79.33	5.70			
Fade-Phobia	STG	25	58.16	8.24	44	3.82	$p<0.05$
	CG	21	46.57	12.18			

The attitude averages of the strategy group for both sub-factors were found higher than the averages of the control group, which can be observed from the results on Table 3.10. The difference between the attitude averages of the groups for both sub-factors was found in favour of the strategy teaching group according to t-test results.

Discussion on Problem-Solving Worksheets

The following results were found based on evaluation of the problem-solving worksheets of students in both groups. Furthermore, these results supported the research results of Israel (2003) and Sarıtaş (2002).

a) The strategies more commonly used, and the behaviors by the solvers who answered correctly compared to solvers who answered incorrectly were; the evaluation of clues, finding better solving steps, realizing usage of wrong solution steps, exploration, another solution, stopping when realizing a misunderstanding, explaining the procedures incorrectly, application of the ideas immediately, determining the equation.

b) The strategies and behaviors much more used shown by the solvers who answered incorrectly compared to those who answered correctly were: tracing solution steps incorrectly, problem-solving by guessing, and misleading calculations.

c) The strategies commonly used and behaviors shown by the solvers who answered correctly and incorrectly were: writing data; plotting a graph, diagram, table, or schematic suitable for problems; usage of each datum; recalling knowledge; guessing the results without calculations; asking questions by oneself; using a control strategy by estimating; finding a relationship; using a formula; and implications.

Generally, it was determined that control of the problem results was not done by the students. This could be caused by anxiety over wasting their time, lack of confidence, lack of proof, and/or shortage of information about these strategies.

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RESULTS AND DISCUSSION

It was determined that the teaching of problem-solving strategies in cooperative groups was effective on the physics achievement of the students. This result of the research was supported by other studies done in the science area such as, Chang and Lederman (1994), Gök and Sılay (2004), Heller, Keith and Anderson (1992), Hollabaugh (1995), Kaptan and Korkmaz (2002), Leonard, Dufrense and Mestre (1996).

Physics lectures generally are given teacher-centrically and theoretically in Turkey. This makes the lectures monotonous, impractical, and memory dependent. The physics lecture is accepted as the hardest lecture in Turkey. The primary reason for this problem is the teaching of physics in a way which does not match with the nature of physics and the students. The ineffective application of planned techniques can be shown as the second reason for the problem. The combination of these two factors causes failure in physics education. Active learning methods help to increase academic achievement by correcting the mistake at the first step.

It was determined that teaching of problem-solving strategies in cooperative groups was effective on strategy usage by the students. This result of the research was supported by other studies made in the science area such as, Leonard, Dufrense and Mestre (1996), Morse and Morse (1995), Park (1990), Tao (2001).

According to our research data, the reason for the strategy group's achievement was the effectiveness of the cooperative learning method for the strategy teaching group, explanation in a systematic configuration of problem-solving strategies, and applying these strategies in a plan. The reason for the failure in the control group's problem-solving strategies was solving problems individually, avoiding information exchange with friends during solving, hesitating to ask about unknown topics or question the teacher or friends, using a solution manual of the problems, using a formula in the incorrect way, place, and time, and also trying to act like a teacher while solving the problem.

The teaching of problem-solving strategies to students in cooperative groups has positive effects, which are sharing knowledge, discussing with friends and teachers, team-working, realizing weak points during team-working and taking precautions, supporting each other, correcting misunderstandings during team discussions, and applying the problem solving strategies in the right place and in the right way.

It is observed that the teaching of problem-solving strategies affects the attitudes of students towards problem-solving. This result supports the studies that looked for a relationship between the learning-teaching strategies and attitudes such as Freedman (1997), Mattern and Schau (2002), Wilson, Ackerman and Malave (2000). Unfortunately, the number of the studies that researched the relationship between strategy teaching and attitudes is quite low.

According to the research results, the reason for the increase in the strategy group's attitude score was the systematic application of problem-solving strategies, information exchange during the team work, paying attention to applied methods, excitement, and supporting and helping each other. The reason for failure in the students' attitude scores in the control group were continuous monitoring of students, teacher-centric lectures, lack of responsibility, and avoiding helping and supporting each other.

Consequently, most of the disadvantages for the control group were tried to be overcome by the application of method. Besides, the compositions written by students clearly showed that students in the strategy teaching groups were much more interested in the physics lecture and developed a positive attitude toward problem-solving.

COMMENTS

According to these results obtained from the research, the following suggestions are presented to program development experts, Ministry of Education authorities, faculties of Education, physics teachers, and all teachers working in different education steps.

a) Teachers should give many more learning activities which develop strategy usage among students in their lectures.
b) The teaching of problem-solving to students in every field facilitates organizing their ideas, developing different thought skills, and building consistent thought models.
c) Other strategies should be researched other than problem-solving strategies in cooperative groups.
d) The students should be observed by means of video-camera and cooperative learning groups' interactions should be monitored for a longer period
e) Teacher candidates in faculties of Education and teachers in service-training should improve themselves in learning and teaching strategies.

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