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INSTRUCTION OF PROBLEM SOLVING STRATEGIES: EFFECTS ON PHYSICS ATTITUDE

ABSTRACT

This study has investigated the effects of problem solving strategies instruction on attitude towards physics course in an introductory physics course at university level. In this study, pretest-posttest and quasi-experimental design with nonequivalent control group was used. Two groups of student teachers (n=77) participated in this study. During the study, one group received the UQAPAC+SE (**U**nderstanding, **Q**ualitative **A**nalyzing, Solution **P**lan, **A**pplying the Solution Plan, **C**hecking + **S**elf **E**valuation) problem solving strategy instruction while the other group received conventional problem solving strategy as control. Data of the study were collected by "Attitude Scale towards Physics Course". Results of the study indicate that strategy instruction was effective on attitude towards physics course. On the basis of this result, it may be recommended that physics instructors should use problem solving strategy instruction in their lessons to increase students' attitude towards physics course.
Keywords: Problem Solving, Strategy Instruction, Physics, Attitude

PROBLEM ÇÖZME STRATEJİLERİNİN ÖĞRETİMİ: FİZİK TUTUMU ÜZERİNDEKİ ETKİLERİ

ÖZET

Bu araştırmada problem çözme stratejileri öğretiminin üniversite düzeyinde fizik dersine yönelik tutumlar üzerine etkileri incelenmiştir. Araştırmada eşitlenmemiş kontrol gruplu ön test-son test araştırma modelinden yararlanılmıştır. Araştırmaya iki grup olmak üzere toplam n=77 öğretmen adayı katılmıştır. Araştırma boyunca bir grup ANAPUK+KD (**A**nlama, **N**itel **A**naliz Etme, Çözüm **P**lanı Yapma, Çözüm Planını **U**ygulama, **K**ontrol Etme+ **K**endini **D**eğerlendirme) üzerine problem çözme stratejisi öğretimi alırken, diğer grup kontrol grubu olarak geleneksel problem çözme stratejisi öğretimi almıştır. Araştırmanın verileri "Fizik Dersine Yönelik Tutum Ölçeği" ile toplanmıştır. Bu sonuç ışığında, fizik öğretmenlerinin öğrencilerinin fiziğe yönelik tutumlarını artırmak için, derslerinde problem çözme stratejilerini kullanmaları önerilmiştir.
Anahtar Kelimeler: Problem Çözme, Strateji Öğretimi, Fizik, Tutum

1. INTRODUCTION (GİRİŞ)

The problem is a new situation which the individuals encountered and where ready methods or instruments to solve it did not exist. Since the problem is a new encountered situation, it is different than an "exercise" or a "question". Solving the problem is a situation requiring the analysis and planning of the learned information [1]

Problem solving is usually defined as formulating new answers, going beyond the simple application of previously learned rules to create a solution [2]. The basic problem solving process is a linear, hierarchical process. Each step is a result of the previous step and a precursor to the next step. Whereas each of these steps is considered as separate skills, each step is categorized into sub skills. These skills can be considered as the analytical parts (heuristics) of the problem solving process which requires defining, investigating, reviewing and processing of the information regarding the problem. Somewhat synonymous term is "strategies". According to the thoughts quoted by Gick [3], Mayer had defined the problem solving strategy as follows: A problem-solving strategy is a technique that may not guarantee solution, but serves as a guide in the problem solving process. In this context; the whole of a problem solving process consists of general and special strategy steps and in field literature mostly defines a problem solving strategy expressed by the initials of the general strategy steps. In the field literature review, like this a lot of problem solving strategies created in mathematics, chemistry, and physics areas were encountered. For instance, in mathematics, STAR strategy [4]; in chemistry RURRR strategy [5] developed for question analysis; in physics GOAL strategy [6]; WISE strategy [7] etc.

Problem solving as a multi-stepped process was firstly introduced on the book called as "How to Solve it" written by George Polya and published in 1945 [6]. This four-stepped process which is well accepted in problem solving and developed by Polya who is a famous mathematician is the first and one of the most popular models presenting the problem solving process by means of "step model" [8]. Four general strategy steps constituting *Polya's strategy* and the special problem solving strategies contained by each step are as follows: (i) *understanding the problem*, (ii) *devising plan*, (iii) *carrying out the plan*, and (iv) *looking back the process* [9].

Also, an important strategy which was benefitted from in problem solving instruction at graduate level in field literature is Minnesota problem solving strategy [10]. This strategy which is developed for "*Introductory to Physics Courses"* and whose modified format is used at the present study is five-stepped. General strategy steps constituting this strategy and the special problem solving strategies contained by each of them are defined as follows respectively: (i) *Visualization of Problem/ Focussing on the Problem* (Sketching an outline expressing the situation on the problem, defining the given and asked datas regarding the limitations, restating the problem, defining the general approach of the problem), (ii) *Physical description* (Creating vector diagram within the scope of defined principles, symbolizing the given and asked quantities, defining the target variable symbolically), (iii) *Making the Solution Plan* (Defining the defined physical concepts and principles in equation form, applying the principles on each object systematically, Performing backward study regarding whether sufficient information to solve the problem was determined or not, and Customizing the mathematical steps to solve the problem), (iv) *Applying the Plan* (Converting the plans into appropriate mathematical operations, Making arithmetical solution), (v) *Checking and Evaluating* (Checking whether the solution is exactly true or not, Checking whether the mark and unit of the solution are true or not, Evaluating whether the magnitude of the given answer is reasonable or not).

These aforementioned step models actually display the processes used by *experts* in other words expert problem solvers during solving well-structured problems [8]. In this context, whether using the problem solving strategies which are the most important components of the problem solving process efficiently or not is an important indicator of being an *expert* problem solver.

Nevertheless, the problem solving skills are not inheritable, but can be learned and improved. Students learn better when opportunities to teach are increased, when they participated into the arranged activities directly, and when they succeeded in solving the presented problems [11].

Cognitive interventions directed to teach the problem solving strategically and systematically are often called as "strategy instruction" [12].

2. RESEARCH SIGNIFICANCE (ÇALIŞMANIN ÖNEMİ)

When the field literature is reviewed, it is seen that most of the studies in physics area related to problem solving strategies are the researches where the differences between experts and novices were determined [13, 14, 15 and 16]. At the same time, it was determined that although there were lots of researches displaying that problem solving strategies instruction had positive effects on the physics problems solving performance [7, 16, 17 and 18] in field literature, however, there were limited numbers of researches displaying the effect of the problem solving strategies instruction on the physics course academic achievement [19 and 20]; it was determined that although there were lots of researches where the effects of the problem solving strategies instruction on the sensory variables such as the attitude towards course in science areas such as mathematics, chemistry, biology were investigated; unfortunately, there was no research where the correlation of the problem solving strategies instruction in physics area with this variable were investigated. Nevertheless, for example there are researches displaying the positive effects of the problem solving strategies instruction in mathematics area on the attitude towards mathematics course [21], the problem solving instruction workshop study on the mathematics teachers' attitudes towards problem solving approach [22], and again the computer-aided problem solving instruction in mathematics on the attitude towards problem solving [23]. Moreover, lots of different researches displaying the positive effects of the problem solving instruction at laboratory instruction in chemistry area on the students' attitudes towards chemistry course had been encountered [24].

In this context, in field literature review, it was seen that lots of researches had been done related to the physics and problem solving strategies abroad. However in Turkey this subject is neglected. When literature in our country related with the subject is examined, unfortunately, there are few studies on determination and usage of the problem solving strategies in science and physics (25, 26 and 27]; and there is only one study on instruction of problem solving [28]. Unfortunately, this subject has not been given importance sufficiently in our training system. Teachers neglect this subject with reasons such as that period of training is limited, that course programs are loaded or that they themselves have sufficient knowledge on that field. In this context, Azar and Çepni [29] stated that the physics teachers, especially the physics teachers who are in first years of their careers scarcely ever introduced the student-centered problem solving activities at the lectures, and these teachers only used the classical traditional instruction containing dictation, and verbal explanation methods as seen from the classroom observations. With such an approach, the possibility of assisting the students to develop the problem solving strategies, and to understand the important concepts and principles is weak. Because, in problem solving, the student benefits from these information in order to solve a new and different situation by analyzing the previous information [1].

For all these reasons, regarding the necessity of investigating the effects of the problem solving instruction on attitude towards course in the field literature, and it is believed that new contributions will be made in the physics education field literature by means of this research.

3. AIM OF THE RESEARCH (ARAŞTIRMANIN AMACI)

Mestre et al. [30] stated that two important goals of physics instruction were to help students achieve a deep, conceptual understanding of the subject and to help them develop powerful problem solving skills. In light of this statement, we designed our problem solving strategy instruction which is integrated content instruction.

In this study, we aimed to determine the effects of the problem-solving instruction on student teachers' attitudes towards physics course. The following research question was posed:

Is there any significant difference between attitudes towards physics course of the students who were applied or not applied the problem solving strategy instruction?

4. METHOD (YÖNTEM)

4.1. Participants (Katılımcılar)

Subjects of this research consist of 77 teacher candidates reading at 2nd grade of Elementary School Mathematics Education Department of Buca Education Faculty of Dokuz Eylül University. They are divided into two branches randomly as A and B where they were selected according to National University Entrance Exam results system and have closer success scores. The reason of performing the research with this group is that having two similar groups which have closer success levels is very convenient for the research model to be done. The students in both branches are responsible from Physics I Course (Mechanical subjects) according to their programs.

In order to keep the natural structure of the class, all of the students registered to Physics I Course are included in the research. The distribution of participants according to gender and groups in this study was presented in Table 1.

Table 1. The distribution of participants according to gender and groups
(Tablo 1. Cinsiyet ve gruplara göre katılımcıların dağılımı)

Gender	Strategy Group		Control Group		*Total*
	n	%	*n*	%	
Male	23	59	12	32	35
Female	16	41	26	68	42
Total	39	51	38	49	77

Note: n: number of participants in groups; %: percentage of participants in groups

However, the data taken from the students whose pre-test and post-test could not be obtained because of their irregular attendance and who did not attend during the experimental process although they were enabled to participate were not taken into consideration. In this context, at some of the data collecting tools, the numbers of students whose data were collected displayed a little alteration.

4.2. Design of Research (Araştırmanın Modeli)

In this study, pretest-posttest quasi-experimental design with nonequivalent control group was used. In this context, the research is conducted with two groups as one control group and one experimental group, namely the strategy group which has similar nature, and was determined by an objective selection.

In the first part of each group, the teacher presented physics concepts, laws and principles by conventional method using textbook. Then, students in the strategy group were taught how to solve physics problems using the problem solving process/strategy, while those in the control group were taught only by course book/traditional problem solving processes/strategies, respectively: 1-Reading the problem, 2-Determining the given and asked variables, 3-Visualizing, 4-Writing down the formulas related to the problem, and 5-Mathematical Solution. The five+one steps of the process are as follows: 1-**U**nderstanding the Problem, 2-**Q**ualitative **A**nalyzing of the Problem, 3-Solution **P**lan for the Problem, 4-**A**pplying the Solution Plan, 5-**C**hecking + **S**elf **E**valuation-(UQAPAC+SE). UQAPAC+SE strategy is somewhat changed form of Minnesota problem solving strategy developed by Heller and his colleagues in 1992. The most important change is that the "self-evaluation" step which is a metacognitive skill was included as detailed with a separate form. Self-evaluation depends on comparing the observed behavior with a target or a standard [31]. These are the activities related to the quality and development of the students' studies.

Both groups were tested before and after the intervention to measure their attitude towards physics course. Control variables were prior attitude towards physics course. The independent variable was the intervention (the problem solving strategy instruction and/or the traditional instruction). The dependent variables were posttest attitude towards physics course.

4.3. Materials (Materyaller)

The data of this study were collected by Attitude Scale towards Physics Course (ASTPC). This measuring instrument was explained in detail below.

4.3.1. Attitude Scale towards Physics Course (ASTPC) (Fizik Dersine Yönelik Tutum Ölçeği (FDYTÖ))

In this research, in order to determine the students' attitudes towards physics course, ASTPC developed by Selçuk [32] was used. This scale containing 5-choice Likert type items having choices of "Very Applicable", "Slightly Applicable", "Undecided", "Not Applicable", and "Totally Not Applicable" consists of totally 40 items. The Cronbach's Alpha reliability coefficient of the scale was found as α= .97. At the end of the factor analysis, it was seen that factor loads of all items were above .40, and these items were collected under two dimensions. Names given to these dimensions, item numbers belonging to sub-dimensions, and Cronbach's Alpha reliability coefficients are respectively as follows: 1-Being interested in (25 items, α= .96), sample items: *"I am interested in everything related to physics", "I am not interested in physics except the lecture hours".* 2-Giving importance (15 items, α= .90), sample items: *"I think that physics lecture is important", "I think that physics is a course that must be* *learned".* The highest score which can be obtained from this scale is 200, and the lowest score is 40.

4.3.2. Intervention Materials (Kullanılan Materyaller)

Turkish translated version of the book PHYSICS for Scientists and Engineers by Serway and Beichner [33] was used as a textbook. Approximately forty well-structured physics problems were selected from this textbook, Fundamentals of Physics [34] and, Physics for Scientists and Engineers [35] for using in the strategy and traditional instruction sessions. During the instruction process, researcher scripts containing information about the six stage problem solving processes/strategies namely Understanding the Problem, Qualitative Analyzing of the Problem, Solution Plan for the Problem, Applying the Solution Plan, Checking + Self Evaluation (UQAPAC+SE) and problem solving work sheets developed by the first researcher were used in the strategy group. Each problem solving sheet contains the problem statement and 5-stepped process in detail. The students studied individually by following the related process on the problem solving sheet in exactly the same way. And self-evaluation strategy usage was performed by a separate form containing the statements and questions providing the evaluation of students' performances(for example: "My knowledges about the subjects of these problems are deficient. Then what else can be necessary to know related to this subject in detail?").

4.4. Procedure (Yapılan İşlemler)

The experimental processes were performed at strategy and control groups on the days and hours separated for Physics I Course on the weekly schedule (2 days per week, and during total lecture hour) on October and November in Fall Semester of 2006-2007 academic year (6 weeks/totally in 24 lecture hours). Before the experimental processes, the pre-tests were taken at the first week when the research started, and at the second week, the problem solving strategies training program was applied to the students in the strategy training group during 8 lecture hours (360 minutes) within one week. The training program prepared about "Thermal Expansion". While the strategy instruction was applied at strategy group, no study relating strategy instruction was carried out in control group. During this period, conventional teaching methods were used in the control group concerning "Thermal Expansion" that is the topic in strategy training program. Both groups were instructed by the same teacher during the experimental processes.

In the research, in training of problem solving strategy, the experts skills gaining approach which is a frequently used approach and one of the main aims of the strategy training, and at the same time similar with the approach in the research of Mestre et al. [30] was used. In the research, in order to provide the novices' problem solving approaches to become as good as the approaches of more expert problem solvers, 5+1 stepped UQAPAC+SE problem solving strategy which presents implicit problem solving strategies used by the experts in a stepped structure and which will help the students to reify these strategies was taught by benefiting from the explicit strategy instruction.

The physics problem solving strategy UQAPAC+SE which is taught in this research is a 5+1 stepped strategy, and each step contains special problem solving strategies within it. In Table 2, the general strategy steps constituting UQAPAC+SE problem solving strategy which is taught in this research and the special strategies were defined.

Table 2. UQAPAC+SE problem solving strategy
(Tablo 2. ANAPUK+KD problem çözme stratejisi)

*1. **U**nderstanding the Problem*

Reading the problem carefully

Restating / writing the problem in his/her own words

Listing the given variables in the problem (with their units)

Listing the asked variables in the problem (with their units)

Visualizing the problem by drawing – drawing diagrams (or establishing correlation between given diagram and the problem)

Determining the scaler and vectorial properties of the given and asked variables

*2. **Q**ualitative **A**nalyzing of the Problem*

Determining the significant (main) concepts of the problem in physics

Determining the general approach of the problem

Expressing the fundamental law/rules related to the problem and why/how to use them

*3. Solution **P**lan for the Problem*

Planning how to achieve the asked variables from the given variables

Writing the formulas related to the problem

Considering whether the physics formulas written for the problem were reasonable or not.

Formulating the final formula before making algebraic operations

Checking whether there was an unknown variable or not in the final formula

*4. **A**pplying the Solution Plan*

Using the given variables in the problem with their units in the formulas

Making the mathematical operations carefully

*5. **C**hecking*

Checking whether all asked variables in the problem were found or not

Considering whether the found result for the problem were reasonable or not

Checking the unit of the result

Reviewing whole solution

+ ***S**elf **E**valuation:* It is a general strategy containing the activities related to the quality and progress of students' works. Problem solver uses this strategy at the end of the problem solving session, and in this stage, the student evaluates his or her behaviors providing him or her to achieve the target on Self Evaluation Form.

In the research, well-structured problems were used. In case of artificial or limited problem, these types of problems requiring application of limited numbers of concepts, rules and principles are encountered especially at the schools and universities; and these problems are typically included in the course books at the end of the chapters and examinations. In this context, in the research, it was paid attention for the solutions of well-structured problems selected from the physics course books during the instruction period to be at least two-stepped, and at the same time as supporting the strategy usage. And difficulty levels of the problems used in the research were designed so as to be done in approximately 7-8 minutes by a successful student and for an unsuccessful student so as to reach to the solution by spending more time (approximately 10-13 minutes).

Instruction of the subjects which are planned to teach within research period at strategy and control groups was begun at the same period and was completed at the same period. During the research period, both groups were maintained to be in parallel.

4.4.1. Activities Performed at Strategy Group (Strateji Grubunda Yapılan Etkinlikler)

At strategy group, after teaching UQAPAC+SE problem solving strategy, then the application of the subjects planned to be taught during experimental process was begun. The subject of that day was instructed by the researcher by using direct lecturing method during the first 90 minutes part of the lecture hours at the course schedule. At the end of the lecture, two sample problems related to subject were solved by the researcher by using UQAPAC+SE problem solving strategy. During the problem solving session hours arranged as the second 90 minutes part of the lecture hours at the course schedule, students solved 6 selected problems related to the subject of the previous lecture at the problem solving worksheets which are handed out to them according to UQAPAC+SE problem solving strategy individually after they reviewed the sample problem related to the subject solved by the researcher at the problem solving worksheet according to UQAPAC+SE problem solving strategy at the first step. During the experimental processes, students were provided to keep the worksheets defining the UQAPAC+SE strategy on their desks. When 15 minutes left to end of the lecture, the problem solving worksheets were collected from the students, at the same time, another problem solving worksheets containing the correct solutions of the problems were handed out to them, and students were wanted to review these correct solutions. During the final 5 minutes of the lecture, the students were wanted to evaluate their problem solving performances on the Self Evaluation Form submitted to them together with the problem solving worksheets at the beginning of the lecture. Problem Solving Worksheets and Self Evaluation Forms collected from the students were reviewed, and the first 10 minutes part of the next lecture hour was allocated to the evaluation of these activities. Deficiencies, and if any, mistakes on the problem solving worksheet were discussed by means of the researcher-student dialogue.

4.4.2. Activities Performed at Control Group (Kontrol Grubunda Yapılan Etkinlikler)

While the strategy instruction was applied at strategy group, no study relating strategy instruction was carried out in control group. During this period, conventional teaching methods were used in the control group concerning “Thermal Expansion” that is the topic in strategy training program. Also at control group, the subject of that day was instructed by the researcher by using direct lecturing method during the first 90 minutes part of the lecture hours at the course schedule. After the instruction of lecture was completed, the same two sample problems solved at strategy group were solved by the researcher at the board for the students at control group by benefitting from only course book/traditional problem solving approach. During the problem solving hours arranged as the second 90 minutes part of the lecture hours at the course schedule, a sample problem related to the subject was solved by the researcher; and then the same 6 problems solved at strategy group were solved also at control group. First, each problem was dictated by the researcher to the students, and then students were given 7-8 minutes to solve the problem. Then a volunteer student who solved the problem solved the problem at the board under the guidance of the researcher. If a problem couldn’t be solved, then the researcher solved that problem by explaining at the board. At the first 10 minutes part of the next lecture, the researcher reminded about the subject and the problems of the previous lecture, then passed on to the other subject.

4.5. Analysis of Data (Verilerin Analizi)

The collected data from the ASTPC was analyzed by SPSS, 11.00 versions. Frequency (n), percentage (%), mean (*M*), standard deviation (*SD*), t-test and effect size (*ES*) were employed. Effect size (*ES*) was computed using Cohen's *d* to measure the magnitude of the intervention effect. Cohen's guidelines [36] were used to classify the magnitude of effect sizes: .20 represents a small effect, .50 a medium effect and .80 a large effect. All statistical tests reported in this paper were conducted with a significance level of $\alpha=0.05$.

5. FINDINGS AND INTERPRETATION (BULGULAR VE YORUM)

5.1. The Effects of Problem-Solving Strategies Instruction on Attitude towards Physics Course (Problem Çözme Stratejileri Öğretiminin Fizik Dersine Yönelik Tutum Üzerine Etkileri)

In order to investigate the effects of the strategy instruction on the students' Attitudes Towards Physics Course, arithmetic means and standard deviations of students' pretest scores belonging to Attitude Scale Towards Physics Course (ASTPC) and two sub-scales of this scale (Being interested in and giving importance) were calculated. The same procedure was repeated also for posttest scores. Independent samples t-tests were used to analyze the differences between the groups (see Table 3).

Table 3. Comparisons between strategy and control groups for ASTPC and sub-scales of ASTPC pretest and posttest
(Tablo 3. FDYTÖ ve alt ölçekleri için strateji ve kontrol grupları arasında ön test-son test karşılaştırmaları)

Sub-scales	*Measure*	*Groups*	*M*	*SD*	*df*	*t-value*	*p-value*
Being interested in	Pretest	SG (n=39)	75.15	19.17	75	.65	.52
		CG (n=38)	72.26	20.09			
	Posttest	SG (n=39)	83.41	17.86	75	2.48*	.01
		CG (n=38)	71.97	22.47			
Giving Importance	Pretest	SG (n=39)	53.58	9.05	75	1.50	.14
		CG (n=38)	50.66	8.04			
	Posttest	SG (n=39)	53.79	9.23	75	2.10*	.04
		CG (n=38)	49.26	9.74			
Whole Scale	Pretest	SG (n=39)	128.74	26.60	75	.96	.34
		CG (n=38)	122.92	26.37			
	Posttest	SG (n=39)	137.20	26.03	75	2.47*	.01
		CG (n=38)	121.24	30.58			

Note: SG=Strategy Group; CG=Control Group
*Statistically significant (significance defined as $p < .05$).

As Table 3 was examined, it was seen that mean values of the pretest scores of ASTPC sub-scales belonging to both groups were close to each other, and the difference between the mean values of groups was insignificant in the dimensions of Being interested in (for strategy and control groups, respectively *M*=75.15, *SD*=19.17; *M*=72.26, *SD*=20.09; $t_{(75)} = .65$, $p = .52$) and giving importance (for strategy and control groups, respectively *M*=53.58, *SD*=9.05; *M*=50.66, *SD*=8.04; $t_{(75)}=1.50$, $p = .14$). Moreover, at the end of the analysis done according to the entire scale, it was seen that the mean value of the pretest scores of the strategy group (*M*=128.74, *SD*=26.60) was higher than that of the control group (*M*=122.92, *SD*=26.37). However, as shown from Table 3, results for the pretest indicated no significant difference in attitudes between the groups ($t_{(75)} = .96$, $p =.34$). These results show that attitudes towards physics course of the students existing in both groups were very close to each other before the experimental study.

As the values belonging to mean values of the posttest scores of ASTPC sub-scales for both groups at Table 3 were examined, it was seen that the differences between the mean values of groups at the scale of Being interested in (for strategy and control groups, respectively M=83.41, SD=17.86; M=71.97, SD=22.47; $t_{(75)}$=2.48, p<.05) and giving importance (for strategy and control groups, respectively M=53.79, SD=9.23; M=49.26, SD=9.74; $t_{(75)}$=2.10, p<.05) after the experimental processes were statistically significant in favor of strategy group. The mean value of the posttest scores of the strategy group (M=137.20, SD=26.03) was higher than that of the control group (M=121.24, SD=30.58). As shown from Table 2, on the posttest, there was statistically significant difference between the groups, in favor of the strategy group ($t_{(75)}$=2.47, p=.01).

Paired samples t-test was undertaken in order to test the differences between the pretest and posttest attitude towards physics course measures for the strategy and control groups. From Table 4, it was determined that the mean values of the post-test scores of the strategy group belonging to both sub-scales (for Being interested in and giving importance, respectively M=83.41, SD=17.86; M=53.79, SD=9.23) were higher than the mean values of the pre-test scores (for Being interested in and giving importance, respectively M=75.15, SD=19.17; M=53.58, SD=9.05); and the difference in the dimension of Being interested in was statistically significant ($t_{(38)}$=3.58, p= .00); however, the difference in the dimension of giving importance was insignificant ($t_{(38)}$= .16, p= .87). Moreover, from Table 4, according to the over-all scale, it can be seen that the improvements from pretest (M=128.74, SD=26.60) to posttest (M=137.20, SD=26.03) for strategy group were statistically significant, ($t_{(38)}$=2.44, p<.05).

Table 4. ASTPC and sub-scales of ASTPC pretest-posttest comparisons for the strategy and control groups
(Tablo 4. FDYTÖ ve alt ölçekleri için strateji ve kontrol gruplarının ön test-son test karşılaştırmaları)

Sub-scales	Groups	Pretest M	Pretest SD		Posttest M	Posttest SD	df	t-value	p-value	Cohen's d
Being interested in	SG(n=39)	75.15	19.17		83.41	17.86	38	3.58*	.00	.57
	CG(n=38)	72.26	20.09		71.97	22.47	37	.14	.88	.02
Giving Importance	SG(n=39)	53.58	9.05		53.79	9.23	38	.16	.87	.02
	CG(n=38)	50.66	8.04		49.26	9.74	37	1.20	.23	.19
Whole Scale	SG(n=39)	128.74	26.60		137.20	26.03	38	2.44*	.01	.40
	CG(n=38)	122.92	26.37		121.24	30.58	37	.58	.56	.09

Note: SG=Strategy Group; CG=Control Group
*Statistically significant (significance defined as p < .05).

On the other hand, from Table 4, it was determined that the mean values of the post-test scores of the control group belonging to both sub-scales (for Being interested in and giving importance, respectively M=71.97, SD=22.47; M=49.26, SD=9.74) were close values to the mean values of the pre-test scores of them (for Being interested in and giving importance, respectively M=72.26, SD=20.09; M=50.66, SD=8.04); the differences between the mean values of pre-test and post-test scores in both dimensions were not statistically significant (for Being interested in and giving importance, respectively $t_{(37)}$= .14, p= .88; $t_{(37)}$=1.20, p= .24). Moreover, from Table 4, according to the over-all scale, it was determined that the mean value of the post-test scores belonging to this group (M=121.24, SD=30.58) was a bit lower than the mean value of the pre-test scores of them (M=122.92, *SD*=26.37). Moreover, it was determined that the difference between the mean values of pre-test and post-test scores was not statistically significant ($t_{(37)}$= .58, p= .56).

When the Cohen's *d* value which gives the effect size of difference between pre-test and post-test scores belonging to total scores of ASTPC of both groups were examined, it can be seen that the effect size at the strategy instruction group (Cohen's *d*= .40) was nearly in middle level; and the effect size at the control group (Cohen's *d*= .09) was very small.

When the Cohen's *d* values which give the effect sizes of difference between pre-test and post-test scores according to total scores belonging to sub-scales of ASTPC for both groups were examined, it can be seen that the effect size at the sub-scale of "Being interested in" (Cohen's *d*= .57) at the strategy group was in middle level; and the effect size at the same sub-scale at the control group (Cohen's *d*= .02) was very small. When the Cohen's *d* values which give the effect sizes of difference between pre-test and post-test scores belonging to "giving importance" sub-scale of ASTPC for both groups were examined, it can be seen that the effect size at the control group (Cohen's *d*= .19) was small; and the effect size at the strategy group (Cohen's *d*= .02) was very small.

6. CONCLUSIONS, DISCUSSION AND SUGGESTIONS (SONUÇLAR, TARTIŞMA VE ÖNERİLER)

As result of the research, having positive effects of the presented problem solving strategies instruction on the students' attitudes towards physics course is consistent with the results of the researches done in field literature. However, it was seen that almost all of these researches were about the attitudes towards mathematics course [21, 22, 37, 38, 39, and 40]; and no research investigating the effect of the problem solving strategies instruction on the attitude towards physics course was encountered in field literature.

Physics course is generally a course which is unliked and qualified as difficult by the students. Mostly, at the physics course done at a traditional environment, the students are in passive positions, and they just listen to the teacher, take notes related to the lesson, and when necessary, write down the problem solved by the teacher or one of their friends on the board to their notebooks. Since the students just deal with the lesson merely at exam periods, and they did not learn the lesson at the lecture hour; they generally tend to memorize the necessary and important parts for the exam, even they study directed to memorize certain problem solutions. And this situation concludes with failure, and thus negative attitudes occur.

All of the students existing at the group where UQAPAC+SE strategy instruction were done were provided to participate into the activities at the problem solving sessions. By this way, each student was forced to solve problem actively, in a sense, to use and apply their knowledge on the problems related to the subject by reviewing all of the knowledge which they learned at the previous lecture. Endeavour to reach to the solution by using the problem solving strategies on the problem solving worksheets had attracted the students' interests, and provided them to feel how important the problem solving was at the physics course; and it was seen that even the students which were uninterested towards course had shown special and great interest to solve the problems. At these sessions where each student actively studies, it was seen that the students made a greater endeavor directed to solve the problems, showed more interest. For these reasons, it is considered that the students' attitudes towards course at the strategy instruction group had been developed positively.

It was determined that there was a significant difference at the attitudes of the strategy group at the pre-test and post-test scores of the attitudes of strategy group and control group and the instruction affected the progress in nearly middle level (Cohen's *d*= .40); however there was no statistically significant difference at the attitudes of the control group and the traditional instruction had almost nonexistent effect on the attitude (Cohen's *d*= .09).

Although a significant difference was determined between the groups in favor of the strategy group in both dimensions of "Being interested in" and "Giving importance" at the post-test scores of the attitudes of the strategy group and the control group; it was concluded that the difference between the pre-test and post-test scores of this group was in statistically significant level in the sub-scale of "Being interested in", whereas in the sub-scale of "Giving importance", the difference between the pre-test and post-test scores was not in statistically significant level. It was determined that the effect of the instruction given to the strategy group on the attitude towards course was in middle level (Cohen's *d*= .57) in the sub-scale of "Being interested in", whereas in the sub-scale of "Giving importance", the instruction had almost nonexistent effect (Cohen's *d*= .02). According to these findings, the importance given to the physics course by the instruction given to the strategy instruction group could not reach to the desired level.

At the same time, according to the findings of the research, although the difference between the pre-test and post-test scores of the attitude scores of the control group both in general and in sub-scales of "Being interested in" and "Giving Importance" was not statistically significant, it was seen that it is high with a very little difference; however it was seen that the effect size defining this change had almost nonexistent effect on total attitude scores (Cohen's *d*= .09) and on sub-scale of "Being interested in" (Cohen's *d*= .02); and had a little effect on sub-scale of "Giving Importance" (Cohen's *d*= .19).

According to these findings, it is thought that although the students gave importance to that course when they first began to take the physics course in graduate level, they thought that they could pass the course by using their knowledge from the high school at the exams by thinking this course which is instructed by the traditional method and which they studied passively as similar to the subjects which they learned before at high school (mechanical subjects), and this caused to slightly decrease the importance level given. From this point, it can be concluded that the strategy instruction was effective on the importance level given to the course, and how importance the strategy instruction was.

On the basis of findings, it may be recommended that physics instructors should use UQAPAC+SE problem solving strategy instruction in their lessons to increase students' attitude towards physics course, and the related outcomes such as problem solving performance. Further research is needed in different educational settings to determine the effects of strategy instruction on the various learning outcomes (e.g. anxiety, scientific creativity, scientific process skills, learning satisfaction and motivation to learning).

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