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The Effect of Physics Education Based on Out-of-School Learning Activities and Critical Thinking on Students' Attitudes *

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Abstract

This study was conducted in 2009-2010 academic year spring semester, with 120 students enrolling to the 9th grade of an Anatolian High School in Ankara. The study consisted of one control group and three experimental groups (Experimental Group A, B and C). In the control group, research was carried out in accordance with the current program. Students in the Group A received the course, based critical thinking and students in the Group B received the course, supported by out-of-school learning activities. Group C received the course, both based critical thinking and supported by out-of-school learning activities. Out-of-school activities were carried out in the Energy Park, Feza Gürsey Science Centre and Middle East Technical University Science and Technology Museum. Pre-test - post-test control group experimental design was applied in the study. To determine the effects of treatments on students' critical thinking dispositions, UF/EMI Critical Thinking Disposition Assessment, which was adapted into Turkish with the researchers, was used. Additionally Attitude toward Physics Course Assessment was used as pre-test and post-test. The results of the study revealed that there are significant differences between students enrolling to different treatment groups with respect to their critical thinking dispositions and their attitudes toward physics course. Using critical thinking education supported by out-of-school science activities in physics will be able to develop students' critical thinking dispositions and attitudes toward physics course.

Keywords

Out-of-school learning
Critical thinking
Critical thinking disposition
Attitude toward physics course
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Introduction

It is seen that many researchers of educational programs and teaching study "thinking" which is built on philosophical, psychological, and educational bases, and they focus on what thinking is, types pf thinking, and education of thinking. The necessity of processing information, as well as teaching information, makes these studies important. As a kind of thinking, critical thinking is significant for individuals and society because it is the kind of thinking during which individuals review and investigate their own and others' thinking processes (Gürkaynak, Üstel & Gülgöz, 2003). Critical thinking is one of the most effective ways of understanding oneself and others.

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Critical thinking is made up of skills and dispositions. The disposition and sincere inclination towards critical thinking means willingness for critical thinking. The most important gateway to be able to think critically is to be willing for critical thinking (Irani et al., 2007). Students can generally be unsuccessful in using the taught skills, and it results from the deficiency in thinking dispositions (Tishman, Jay & Perkins, 1993). As the critical thinking disposition is one of the most important requirements for developing critical thinking skill, the ways to develop critical thinking disposition must be emphasized for students to use critical thinking skills.

Two fundamental teaching approaches are mentioned in developing critical thinking. The first approach is related to teaching critical thinking based on skills and other is teaching it based on content. In teaching critical thinking, skill based approach uses researches which are not closely related to any subjects or scientific braches; content based approach is the educational approach which integrates critical thinking skills into content and information in teaching programs (Feuerstein, 1999). As the advocates of content based teaching approach, Paul, Weil & Binker (1990) state that critical thinking skills can be instilled in any content.

The methods and techniques chosen to educate the subjects in education programs and the created education environments may support developing students' thinking skills. Problem-based learning, six hats, socratic questioning, role play, simulations, brainstorming, reverse brainstorming, and use of concept maps, flow charts, decision-making tree, diagrams, analogies and metaphors are considered as effective methods and techniques on developing critical and creative thinking (Jay Bonk & Stevenson Smith, 1998). In addition to that, the intellectual atmosphere of the school and the examples provided by teachers have the same significant effect. Wishing their students to think creatively and critically, teachers as models must demonstrate these skills. Another requirement is to reorganize the learning environment to develop students' thinking skills (Marzano et al., 1988). In this view, the importance of providing learning environments where students can feel comfortable and investigate deeply.

Informal learning environments are where students feel more comfortable compared to formal learning environments. Informal environment encourages learning in ways that a traditional environment may not. A variety of different learning styles can be accommodated, and s/he can take in information at his/her own pace; s/he can spend more time with exhibits and from these construct his/her own sense of relevance (Melber & Abraham, 1998). Therefore, it is important to make the connection between informal teaching and formal teaching (Eshach, 2006). Out-of-school education is the type of education, which based on teaching programs, makes use of fields and institutions apart from school building during education time. It uses informal education resources for formal education. It forms the connection between informal and formal education. When museums, science centres, zoos, botanic parks, aquariums, planetariums, all of which informal education environments, are used for formal education, they may have different effects on students' interests, attitudes, and learning levels (Salmi, 1993).

In this study, several informal learning environments, which are a science centre, an energy park and a planetarium, were used for formal education and the activities that carried out, were defined as out-of-school learning activities. This study aims to investigate the effect of physics educations, based on critical thinking training, supported with out-of-school scientific activities, on students' critical thinking dispositions and attitudes towards physics courses.

The Importance of the Study

There are numerous studies on critical thinking in literature. It may be stated that many of the conducted studies are related to critical thinking training in many fields and investigate the effect of the methods in use on the students' critical thinking skills and disposition, besides of case studies on the subject (Akbıyık & Seferoğlu, 2002; Akınoğlu, 2001; Bapoğlu, Açıkgöz, Kapısız & Yılmaz, 2011; Eldeleklioğlu & Özkılıç, 2008; Kurnaz, 2007; Küçük & Uzun, 2013; Yıldırım & Şensoy, 2011). Recently, it is seen that there is an inclination towards studies on out-of-school learning activities. The idea that it is necessary to use informal environments for formal education is developing, but the difficulty of out-of-school learning activities limits the number of informal environments where these activities are conducted for research. In researches related to science centres where out-of-school scientific activities are conducted, it could be said that, the effect of conducted activities on students' attitudes, motivations, and success are generally investigated (Bozdoğan, 2007; Knapp, 2000; Lewalter & Geyer, 2009; Salmi, 1993; Şentürk, 2009).

Unlike other research in this study, physics course was conducted based on critical thinking and supported with out-of-school learning activities. This study aims to investigate the effects of this course, which conducted with including both processes, on students' attitudes towards physics course and critical thinking dispositions.

It is known that changing attitudes and dispositions takes time. Considering that one or two out-of-school activities would not be sufficient to determine students' attitudes and disposition, out-of-school scientific activities in this study are planned, which paralleled with the curriculum, and conducted through spring semester of 2009-2010 academic year.

It is seen that there were radical alterations in high school physics program since 2007, providing activities suitable for constructive approach. High school physics program identified critical thinking skills under the title of "problem solving skills" (MEB, 2007). It is appeared that, this program, which based on student centred learning theories, aimed to develop higher-level thinking skills of students.

This study will attempt to supply alternative learning implementations, both including out-of-school activities and developing critical thinking skills for teachers and researchers. This study is also aimed to be a guide for other researchers, in this subject.

Problems and Sub-Problems

The main aim of the study is to examine the effects of physics education based on critical thinking supported with out-of-school learning activities on ninth grade students' critical thinking dispositions and attitudes towards physics course, in terms of the other teaching processes, which based on critical thinking, out-of-school learning activities, and existing education. In the frame of the main aim of the study, the sub-problems are as follows:

What are the effects of teaching processes, which are based on (1) critical thinking supported with out-of-school learning activities, (2) critical thinking, (3) out-of-school learning activities and (4) existing education on ninth grade students' critical thinking dispositions?

What are the effects of teaching processes, which are based on (1) critical thinking supported with out-of-school learning activities, (2) critical thinking, (3) out-of-school learning activities and (4) existing education on ninth grade students' attitudes towards physics course?

Method

The research has a pre-test post-test quasi-experimental design. The research was carried out with four groups, which control group, experiment A, experiment B, and experiment C. Three experimental procedure steps were applied in the research. These are, physics course based on,

- Critical thinking (conducted for experiment group A)
- Out-of-school learning activities (conducted for experiment group B)
- Both critical thinking and out-of-school learning activities (conducted for experiment group C).

As the pre-test, Critical Thinking Disposition Instrument (CTDI) and Attitude toward Physics Course Instrument (ATPCI) were applied to all the groups before the experimental process. Upon the completion of experimental process, CTDI and ATPCI were applied again. Physics course based on critical thinking for research groups was conducted by the course teacher. The application of out-of-school learning activities was mostly carried out by the experts, employed in those institutions.

Study Groups

The research was conducted with 120 ninth grade students in a high-school institution in Ankara during spring semester in 2010. All the students are in the same age group (aged 14 and 15). Appropriate sampling method was used in student selection, and students' physics grades from the previous year were evaluated for grouping. The similar classrooms each other were preferred in terms of students' physics grades while deciding which classrooms would be included in research groups. Student numbers in research groups are given in Table 1.

Table 1. Number of Students in Control and Experiment Groups

	Number of Students		
Groups	**Girl**	**Boy**	**Total**
Control	25	5	30
Experiment A	20	10	30
Experiment B	21	9	30
Experiment C	17	13	30

Permissions were obtained from the school and National Education Directorates in order to perform out-of-school activities. Dates were set by contacting the institutions where out-of-school activities were to be performed. Each group consisted of 30 students.

Application

Developing/teaching critical thinking skills: During the study period in spring semester of 2009-2010, the students in experiment A and C groups received in-class content-based critical thinking education in force-motion and electric-magnetism topics of ninth grade physics course program. Critical thinking skills and strategies were integrated into units in content-based critical thinking approach which teaches critical thinking along with the planned content. Strategies related to critical thinking defined by Paul, Weil et al. (1990) were taken as a basis in order to develop critical thinking skills, are given in Table 2.

Table 2. Strategies Integrated into Contents

• Thinking independently • Developing intellectual perseverance • Comparing analogous situation • Evaluating the credibility of sources of information • Analysing or evaluating arguments, interpretations, beliefs or theories • Reading critically • Making interdisciplinary connections • Examining or evaluating assumptions • Making plausible inferences, predictions or interpretations	• Recognizing contradictions • Developing intellectual perseverance • Developing confidence in reason • Clarifying issues, conclusions or beliefs • Questioning deeply • Generating or assessing solutions • Listening critically • Noting significant similarities and differences • Distinguishing relevant from irrelevant facts • Evaluating evidence and alleged facts • Exploring implications and consequences

Lessons were conducted by course teachers. A teachers' guide was prepared for this purpose. It included critical thinking, critical thinking disposition, and methods of developing critical thinking, along with course plans for force-motion and electric-magnetism topics prepared according to content-based critical thinking education method. One teacher, two physics trainer, and one expert on critical thinking were consulted about the conformity of the course plans with content-based critical thinking education and existing teaching plan. Before the research, course teachers were informed about critical thinking, critical thinking disposition, methods of developing critical thinking and basics of content-based critical thinking education Course plans in teachers' guide were explained to course teachers in detail. Implementing the course plans in teachers' guide by course teachers was provided throughout the process.

The steps followed to conduct content-based critical thinking education in physics course are as follows:

- Analysis of ninth grade high school physics teaching program,
- Determining the gains from the topics given in physics course
- By analysing critical thinking strategies, determining what perform along with course gains
- Determining critical thinking skills to be developed based on these strategies
- Determining the time for topics
- Determining introductory activities
- Determining methods/techniques to be used to develop chosen critical thinking skills
- Determining and developing required course equipment
- Determining questions groups to be asked during course period and preparing them
- Determining supplementary work.

During the introduction activities, volunteer students presented a slide show for the first ten minutes, which was prepared before the class, on a physics topic they were curious about. Worksheets about the topic were handed out to students during the class. In the lessons which were student-focused, inquire method was rather emphasised, and discussion method was preferred. Socratic questions groups were used which were based on "why" questions during the application of lessons. These Socratic questions groups are; Group 1: Questions of clarifications, Group 2: Questions that probe assumptions, Group 3: Questions that probe reasons, evidence and causes, Group 4: Questions about viewpoints or perspectives, Group 5: questions that probe implications and consequences, Group 6: Questions about the question (Paul, Binker et al., 1990). It was supported to be perceived a democratic learning atmosphere by students. Every student who wanted to express his/her idea, answer questions, or ask a question was heard as much as possible, and they were encouraged to voice their ideas whether right or wrong. As supplementary work, all students were tasked to ask "their best questions" about the topic. Force and motion issues, prepared on the basis of the organizational chart of the course is presented in the appendix.

Out-of-school learning activities: It was conducted with students in experiment group B and C together. The first application of out-of-school learning activities was performed in MTA Energy Park, and following applications were in Middle East Technical University (METU) Museum of Science and Technology, and Feza Gürsey Centre of Science. The activities in METU Museum of Science and Technology consisted of two phases; the first one was the application with physics experiments, and the other was the planetarium activity. The course contents and course order were taken into consideration while planning out-of-school activities. Therefore, ninth grade program was analysed first. The performed out-of-school learning activities were conducted in such a way to support critical thinking. There were meetings with experts to inform them about the aim of the study before the applications in MTA Energy Park, Feza Gürsey Centre of Science, and METU Museum of Science and Technology.

The activities in the Energy Park were conducted with the guidance of the experts employed in that institution. Experts were informed about the study and the aim of the study. In this respect, question-answer method was used mostly in the activity performed in Energy Park.

There were two different applications as experiment activity and planetarium activity in METU Museum of Science and Technology. The expert and the researcher carried out a joint work on the teaching method to be applied in the activities in METU Museum of Science and Technology. In experiment activity, the experiment sets in the museum were abided, but mainly the experiment sets about force-motion and electric-magnetism were used. Before the application, the researcher prepared a lesson plan based on critical thinking skills and determined questions to be asked and topics to be discussed. Planetarium activity was conducted in two parts as "inside the planetarium" and "the garden of the museum". The shows, named Astronaut (23 minutes) and Oasis in Space (28 minutes), were displayed to the students inside the planetarium. During the shows, students were asked questions regarding the force-motion topic. In addition, it was benefited from a program, named Stellarium, to be a visual experience about the sky for the students. Stellarium is a computer program that can be projected the sky on the screen, according to the specified coordinates. The activity conducted in the garden of the museum, accuracy of two scientific articles located in one of the daily newspapers have been discussed with the guidance of the expert.

Rendezvous were taken from the institutions as suitable dates for out-of-school activities were set. Permission from District Directorates for National Education was taken together with consent from parents.

Existing Education: The existing education program theoretically has attached importance about gaining high-level thinking skills, which critical thinking skills included. “Teacher Observation Form”, developed by Şengül (2007), was used to determine if it was realized in practice and to investigate the implications of the activities in control and experiment groups, in terms of development levels of students’ critical thinking skills. The form had ten items, containing cognitive behaviours, and six items containing emotional behaviours. After the investigations, it was seen that level of using critical thinking activities containing cognitive and emotional behaviours was inadequate but groups of experiment A and C were adequate.

Data Collection Tools

In order to carry out the application and to conduct validity-reliability studies of data collection tools, studies were conducted in three separate high-school institutions during the first and second semesters in 2009-2010 academic year with permissions from National Education Directorate of Ankara Governorship.

Attitude toward Physics Course Instrument and Critical Thinking Disposition Instrument, which was adapted to Turkish, were utilized as data collection tools. UF/EMI Critical Thinking Disposition Instrument, adapted to Turkish by Ertaş Kılıç & Şen (2014), was utilized to measure students' critical thinking disposition. The scale is structured as five-point Likert-type, and the internal validity score is 0,91. In the present study, the validity score of the pre-test of the scale is 0,88 and that of the post-test is 0,89.

The instrument, developed by Kocakülah & Kocakülah (2006) with a reliability coefficient of 0,96 for physics course, was used as a pre-test and post-test to find out the effect of the applied process on students' attitudes toward physics course. Communication with e-mails was initiated and consent was taken to use the scale which was applied as a pre-test and post-test in the research. The reliability coefficient of the scale was determined as 0,96 for pre-tests and 0,97 for post-tests in the research.

Analysis of Data

In order to do the statistical analysis, firstly the data set has to be prepared by being organized for analysis. Therefore, the missing values and outliers in the data set were analysed. Descriptive statistics were benefitted to determine the general features of the groups, and mean, standard deviation, frequency and percentages which were acquired from applied quantitative data collection tools, were calculated and analysed in terms of the research problem.

When variable numbers and types were evaluated, it was decided to use multivariate analysis of covariance (MANCOVA), one of the methods of multivariate statistics method, for the inferential statistics of the data (Çokluk, Şekercioğlu & Büyüköztürk, 2010). Some multivariate analyses have supposition of their own. Nevertheless, all the analyses depend on three fundamental suppositions (Çokluk et al., 2010). To test if MANCOVA suppositions were met or not, univariate and multivariate normality, univariate and multivariate linearity, equivalence of variance and covariance, and the homogeneity of regressions were analysed.

As the number of dependent variables was two, and in order to increase the strength of MANCOVA statistical test, α=0,05 value was divided by two, and significance level was accepted as α=0,025. In the analyses based on univariate, ANCOVA statistical test was used. Microsoft Excel 2010 and SPSS 20 programs were used to analyse the data.

Internal and External Validity of the Study

Some possible threats which might effect internal and external validity during the study period were kept under consideration (Fraenkel, Wallen & Hyun, 2011). The study was conducted with ninth grade secondary school students. They are within the same age group (14-15 years). The in-class education was performed by two different teachers during the study. A teacher conducted courses in groups with present education methods, and a different teacher carried out physics course based on critical thinking in other groups. The teachers were informed about the program in groups where physics course was given based on critical thinking skills. A teacher guidebook was prepared for said teachers to apply the course plans in their groups. The reason why two different teachers were selected for two different methods was the existing concerns about the fact that content based teaching of critical thinking in physics course might influence the teacher and that present method might not be applied. Pre-tests and post-tests were applied to students in their own classrooms by the researcher. Applying pre-tests to students is one of the cases decreasing internal validity. However, post-tests were applied to students approximately three and a half months after the pre-tests.

Results

This section presents the preparation of data for analysis, the findings resulting from descriptive statistics of quantitative data, analysis of suppositions for MANCOVA, and findings resulting from the inferential statistics.

Preparation of the Data for Analysis

In order to acquire valid results from the data, it is firstly important to analyse the quality of the data. Therefore, the effects of lost data and extremes in the data set were analysed. The mean score calculated for each item was assigned instead of lost values. Z scores over total scores were calculated to define one-way extremes. When Z scores were analysed, it was observed that all the scores are within the range of +3 and -3 (Çokluk et al., 2010). Versatile extremes were attempted to be calculated by analysing Mahalanobis distance, a statistical method used in defining extremes (Tabachnick & Fidell, 2007). It was determined that all the Mahalanobis values are smaller than Chi-Square table values (χ^2=18,47, df=4, p=0,001).

Additionally, in order to use multivariate statistical techniques, some suppositions had to be met. The findings resulted from the analysis of suppositions required for MANCOVA, the preferred analysis method.

Normality and Linearity: The results belonging to univariate and multivariate normality were analysed. For univariate normality, kurtosis and skewness values for each variant and histogram graphics for these values were analysed, and normality test was conducted. The descriptive statistics values for variants are given in Table 3.

Table 3. The Descriptive Statistics of Variables

Data Collecting Instrument		N	Min.	Max.	Mean	SD	Skewness	Kurtosis
CTDI	Pre-test	120	60	123	96,26	12,614	-0,594	0,322
	Post-test	120	65	124	100,17	11,925	-0,414	-0,148
ATPCI	Pre-test	120	34	141	92,94	24,857	-0,580	-0,410
	Post-test	120	33	148	101,08	28,545	-0,640	-0,458

When Table 3 is analysed, it is seen that kurtosis and skewness values of normality are between +1 and -1.

Homogeneity: Levene test and Box's M test was utilized to investigate homogeneity of dependent variables. Univariate homogeneity was tested with Levene test, and Box's M test was used to test multivariate homogeneity. Statistics results for Levene test of pre-tests of dependent variables are presented in Table 4.

Table 4. Levene Test Results of Pre-tests and Post-tests of Dependent Variables

Variables		F	df1	df2	Sig.
CTDI	Pre-test	0,480	3	116	0,697
ATPCI	Pre-test	2,689	3	116	0,050
CTDI	Post-test	2,225	3	116	0,089
ATPCI	Post-test	5,824	3	116	0,001

When univariate homogeneity belonging to pre-tests of dependent variables was analysed in terms of the types of teaching methods as independent variables, it was seen that all the variables met homogeneity supposition.

When univariate homogeneity belonging to post-tests of dependent variables was analysed, it was seen that critical thinking disposition assessment instrument met homogeneity supposition, yet attitude toward physics instrument did not meet homogeneity supposition. However, it was determined that variance rate between groups in post-test of physics attitude instrument was found out to be less than four (Kalaycı, 2005). Therefore, it was accepted that univariate homogeneity supposition was met.

Evaluating the multivariate homogeneity, it was seen that the result of Box's M test (p= 0,042) was not significant. The fact that Box's M test was not significant (p>0,025) means variance-covariance matrixes were homogeneous (Çokluk et al., 2010). Due to the result acquired from Box's M test, it may be stated that multivariate homogeneity is met (Tabachnick & Fidell, 2007). Besides, the study was carried out with groups of the same number (n=30). According to the results, it may be expressed that statistical analysis is reliable.

Descriptive statistical findings of the critical thinking disposition scale

Table 5 presents descriptive statistical values of pre-tests and post-tests of the critical thinking disposition scale.

Table 5. Descriptive Statistics of the Critical Thinking Disposition Instrument

Dependent Variable	Groups	Pre-test		Post-test	
		Mean	SD	Mean	SD
Critical Thinking Disposition	Control Group	95,43	13,263	91,40	11,634
	Experiment A	95,27	13,292	100,13	11,398
	Experiment B	92,67	11,565	98,93	9,116
	Experiment C	101,67	11,012	110,23	7,021

The maximum score that CTDI is 125 while the minimum is 25. Critical thinking disposition averages point out a decline in the control group but an incline in the experiment group. Standard deviation values are close in pre-tests while there is differentiation in post-test.

Descriptive statistical findings of the attitude toward physics course

Descriptive statistical values of pre-tests and post-tests of the attitude toward physics course scale in terms of groups are given in Table 6.

Table 6. Descriptive Values of the Attitude toward Physics Course Scale

Dependent Variable	Groups	Pre-test		Post-test			
		Mean	SD	Mean	SD	Max.	Min.
Attitude Toward Physics Course	Control Group	89,70	27,964	83,93	32,594	150	30
	Experiment A	84,23	25,964	92,80	25,486	150	30
	Experiment B	98,77	22,037	107,77	23,443	150	30
	Experiment C	99,07	20,746	119,83	17,231	150	30

The total mean scores of the ATPCI display decline in the control group and increase in the experiment groups. It can be said that standard deviation values for ATPCS pre-test do not differentiate much while there is some differentiation in the post-test.

Inferential statistics findings

Variance analysis (ANOVA) was conducted to find out if experiment and control group students' critical thinking dispositions and attitude toward physics course are different in the pre-tests. Pearson correlation coefficients were used to determine the significance between pre-tests and post-tests. According to ANOVA results, there wasn't a statistically significant difference ($F_{(3,116)}$=2,884; p>0,025) between the pre-test CTDI mean scores of the students in the experiment and control groups. According to the acquired ANOVA results, there wasn't a statistically significant difference ($F_{(3,116)}$=2,661; p>0,025) between the pre-test ATPCI mean scores of the students in the experiment and control groups. It was also found out that there is a significant relation between CTDI pre-test scores and CTDI post-test scores ($r_{(120)}$=0,578, p<0,01); and between ATPCI pre-test scores and ATPCI post-test scores ($r_{(120)}$=0,761, p<0,01). MANCOVA is effective when the correlation between covariant and dependent variant is higher than 0,3 (Kalaycı, 2005). Therefore, students' pre-test scores of CTDI and ATPCI were assigned as covariant.

After controlling the acceptance of covariant variance analysis, MANCOVA analysis was conducted to answer the general problem of this study by testing at 0,025 alpha level. CTDI and ATPCI post-test mean scores resulted from MANCOVA statistical test conducted to answer this problem and mean score adjusted according to covariates (CTDI pre-test and ATPCI pre-test) are given in Table 7.

Table 7. CTDI and ATPCI Post-test Mean Scores of the Group and Adjusted Mean Scores

	Group	n	Mean	Adjusted Mean
CTDI Pre-test	Experiment C	30	110,233	107,529
	Experiment A	30	100,133	101,459
	Experiment B	30	98,933	99,648
	Control Group	30	91,400	92,065
ATPCI Post-test	Experiment C	30	119,833	113,189
	Experiment B	30	107,767	105,117
	Experiment A	30	92,800	99,434
	Control Group	30	83,933	86,594

When CTDI and ATPCI pre-test mean scores are checked, it is seen in Table 7 that there are changes in CTDI and ATPCI post-test averages.it is observed that mean difference between the post-test averages of the groups. MANCOVA analysis results are given in Table 8.

Table 8. MANCOVA Results on the General Problem of the Research

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Square
Pillai's trace	0,453	11,124	6	228	0,000	0,226
Wilks' lambda	0,560	12,690	6	273	0,000	0,252

This result shows that it is a significant difference in ninth grade high-school students' averages of critical thinking disposition and averages of attitudes towards physics course among the groups (Experiment A, Experiment B, Experiment C and Control Group). Eta square value was acquired as 0,226. This result shows that the effect magnitude is large and that almost 23% of the change in dependent variables results from the application.

ANCOVA results based on groups' post-test scores adjusted according to CTDI and ATPCI pre-tests are presented in Table 9.

Table 9. ANCOVA Results Based on Groups' Post-test Scores Adjusted according to CTD and ATPC Pre-tests

Source	Dependent Variable	Sum of Square	df	Mean Square	F	Sig.	Partial Eta Square
CTDI Pre-test	CTDI Post-test	1977,158	1	1977,158	32,619	0,000	0,222
	ATPCI Post-test	2464,142	1	2464,142	10,595	0,001	0,085
ATPCI Pre-test	CTDI Post-test	652,402	1	652,402	10,763	0,001	0,086
	ATPCI Post-test	27794,211	1	27794,211	119,508	0,000	0,512
Group	CTDI Post-test	3544,015	3	1181,338	19,490	0,000	0,339
	ATPCI Post-test	10905,733	3	3635,244	15,631	0,000	0,291
Error	CTDI Post-test	6909,906	114	60,613			
	ATPCI Post-test	26513,214	114	232,572			
Total	CTDI Post-test	16923,325	119				
	ATPCI Post-test	96961,167	119				

As seen in Table 9, CTDI post-test, ATPCI post-test scores state a significant difference separately for each group. The values indicate a large influence based on groups in all the tests.

Findings of sub-problem of the study

After reviewing CTD and ATPC pre-tests, the results based on univariate are given in Table 10. As seen there, it was revealed the result ($F_{(3,114)}$=19,490; p<0,025) for the first sub-problem of the study. So, experiment groups (Experiment A, Experiment B, Experiment C and Control Group) state a significant difference between ninth grade high-school students' averages of critical thinking disposition.

Table 10. Results Based on Univariate After Reviewing CTD and ATPC Pre-tests

Dependent Variable		Sum of Square	df	Mean Square	F	Sig.	Partial Eta Square
CTDI Post-test	Contrast	3544,015	3	1181,338	19,490	0,000	0,339
	Error	6909,906	114	60,613			
ATPCI Post-test	Contrast	10905,733	3	3635,244	15,631	0,000	0,291
	Error	26513,214	114	232,572			

As seen in Table 10, it was revealed the result ($F_{(3,114)}$=15,631; p<0,025) for the second sub-problem of the study. So, experiment groups (Experiment A, Experiment B, Experiment C and Control Group) states a significant difference between ninth grade high-school students' averages of attitudes towards physics course. Table 11 provides information on multi-comparisons according to Bonferroni test results.

Table 11. Multi-Comparisons Results Based on Dependent Variables

Dependent Variable	Group (I)	Group (J)	Mean Difference (I-J)	Std. Error	Sig.	%97,5 Confidence Interval	
						Lower Bound	Upper Bound
CTDI Post-test	Control	Experiment A	-9,394*	2,018	0,000	-15,295	-3,493
		Experiment B	-7,583*	2,053	0,002	-13,587	-1,579
		Experiment C	-15,464*	2,047	0,000	-21,450	-9,478
	Experiment A	Control	9,394*	2,018	0,000	3,493	15,295
		Experiment B	1,811	2,093	1,000	-4,309	7,932
		Experiment C	-6,070	2,067	0,024	-12,115	-,025
	Experiment B	Control	7,583*	2,053	0,002	1,579	13,587
		Experiment A	-1,811	2,093	1,000	-7,932	4,309
		Experiment C	-7,881*	2,095	0,002	-14,006	-1,756
	Experiment C	Control	15,464*	2,047	0,000	9,478	21,450
		Experiment A	6,070	2,067	0,024	,025	12,115
		Experiment B	7,881*	2,095	0,002	1,756	14,006
ATPCI Post-test	Control	Experiment A	-12,839*	3,953	0,009	-24,399	-1,280
		Experiment B	-18,522*	4,022	0,000	-30,283	-6,762
		Experiment C	-26,595*	4,010	0,000	-38,320	-14,869
	Experiment A	Control	12,839*	3,953	0,009	1,280	24,399
		Experiment B	-5,683	4,100	1,000	-17,672	6,306
		Experiment C	-13,755*	4,049	0,006	-25,596	-1,914
	Experiment B	Control	18,522*	4,022	0,000	6,762	30,283
		Experiment A	5,683	4,100	1,000	-6,306	17,672
		Experiment C	-8,072	4,103	0,309	-20,070	3,925
	Experiment C	Control	26,595*	4,010	0,000	14,869	38,320
		Experiment A	13,755*	4,049	0,006	1,914	25,596
		Experiment B	8,072	4,103	0,309	-3,925	20,070

According to Table 11, there is significant difference in favour of the experiment groups; between the control group's and the experiment groups' CTDI post-test mean scores. Nevertheless, there aren't any significant differences between experiment group A and experiment group B; and between experiment group A and experiment group C. Between experiment group B and C, there is significant difference in CTDI post-test mean scores in favour of experiment group C.

As inferred from Table 11, there is significant difference in favour of experiment groups between the ATPCI post-test mean scores of students in the control group and the experiment groups. ATPCI post-test mean scores do not indicate significant difference between experiment group A and B. Between experiment group A and C, there is significant difference in favour of experiment group C. there is no significant difference between experiment group B and C.

Discussion, Conclusion and Suggestions

This study aimed to investigate the effects of physics education, based on critical thinking supported with out-of-school learning activities, on ninth grade high-school students' critical thinking dispositions and attitudes towards physics course, in terms of the other teaching processes, which based on critical thinking, out-of-school learning activities, and existing education.

When we evaluate the results in terms of students' critical thinking disposition; it is concluded that the education, which based on critical thinking supported with out-of-school learning activities, critical thinking, and out-of-school learning activities are more effective in increasing students' critical thinking dispositions compared to the existing education. The result indicating that critical thinking education effects students' critical thinking disposition more positively compared to the existing education shows a similarity with Kurnaz (2007), Yıldırım & Şensoy (2011). Kurnaz (2007) concluded content-based critical thinking training activities effected primary students' critical thinking disposition positively. Yıldırım & Şensoy (2011) investigated the effects of science course based on critical thinking on primary students' critical thinking disposition and concluded science course based on critical thinking increased primary students' critical thinking disposition in comparison to existing education.

When we evaluate the results, about the development of students' critical thinking disposition, there is no significant difference between physics course based on critical thinking and physics course supported with out-of-school learning activities. On the other hand, physics course based on critical thinking supported with out-of-school learning activities is more effective than physics course based on out-of-school learning to develop students' critical thinking disposition. This result reflects the value of effects of physics course, based on critical thinking, in developing students' critical thinking disposition, in comparison to other physics courses without critical thinking.

When the findings are evaluated in terms of students' attitudes towards physics course; it is concluded that physics course based on critical thinking supported with out-of-school learning activities, physics course based on critical thinking, and physics course supported with out-of-school learning activities are more effective than the physics course based on existing education in increasing students' attitudes towards physics course.

It is observed that physics course based on critical thinking supported with out-of-school learning activities is more effective than physics course based on critical thinking in increasing students' attitudes towards physics course. No significant difference was observed between physics course based on critical thinking and physics course supported with out-of-school learning activities, in terms of increasing students' attitudes towards physics course. The evaluation of the acquired results expresses the importance of effect of out-of-school learning activities in developing students' attitudes toward physics course. The results are similar with the studies by Bozdoğan (2007); Knapp (2000); Lewalter & Geyer (2009); Şentürk & Özdemir (2014).

Bozdoğan (2007) concluded that the tools and activities in Feza Gürsey Science Centre and Energy Park greatly effected developing and sustaining students' interest towards and academic success in science topics. In his study on the effect of scientific field trips on the permanency of knowledge, Knapp (2000) reached the conclusion that what students remember is disconnected and unspecific knowledge compared to what teachers provide. He also concluded that students developed positive attitudes to acquire further knowledge about topics. In a study by Lewalter & Geyer (2009), it was stated that using museum as learning environments provided a high level of motivation. The study by Şentürk & Özdemir (2014) investigating the effect of Middle East Technical University Science Centre on 11-14 years old 6th grade students' attitudes towards science shows that science centres are a greatly effective way to increase students' attitudes towards science.

This study states the positive effects of out-of-school learning activities on developing ninth-grade high-school students' attitudes toward physics course. However, the result indicating that physics course supported with out-of-school learning activities and physics course based on critical thinking have effects at the same level shows that physics course based on critical thinking in the class is also effective in increasing students' attitudes.

Considering the effects of physics course based on critical thinking supported with out-of-school learning activities, the results show that it is not enough to conduct only physics course supported with out-of-school activities or only the physics course based on critical thinking in the classroom. However, when physics course based on critical thinking is supported with out-of-school learning activities, it can be more effective on students' disposition towards critical thinking and attitudes towards physics course.

It is clear that critical thinking is vital for individuals and society. Rote learning, which can be viewed as the largest barrier against achieving meaningful learning is encountered in physics course where thinking can be assumed to exist at the highest level. It is thought that this study could be beneficial for teachers to educate individuals who are questioning, inquiring, and inquisitive, and to guide how to be applied critical thinking education in physics course.

It can be beneficial if teachers plan out-of-school learning activities along with developing critical thinking in physics course. In planning out-of-school activities, it is required to cooperate with science centres and bridge them with schools for students' cognitive and emotional gains, beyond having fun. Out-of-school activities planned cooperatively by teachers and experts will be significant for increasing students' attitudes towards courses and developing their critical thinking dispositions. It is also thought to be beneficial to include elective courses on out-of-school learning activities in teacher training programs for teacher candidates. The increasing number of such courses in university curriculums lately is pleasing. It is thought that the obtained results from the study can be also beneficial to determine the form to place critical thinking and out-of-school activities in physics course teaching programs.

There is need for more studies to be conducted on developing out-of-school learning and critical thinking. Conducted out-of-school activities are limited to those in energy parks, science centres, and planetariums. Further studies may be performed on out-of-school learning activities in different informal environments. Studies on the effect of out-of-school learning on different dimensions such as students' career choices, learning styles, acquisition of terminology will help define the effects of out-of-school learning.

It is important to promote science centres, museum of science and technology, and planetariums, which teachers can benefit as out-of-school learning locations, throughout the country. In this regard, with the framework decision of High Council of Science and Technology, The Scientific and Technological Research Council of Turkey (TÜBİTAK) initiated a support program, called Science and Society Project. In this context, TÜBİTAK supports the projects of science centre establishment by metropolitan municipalities (TÜBİTAK, 2014). Besides, science centres formed in universities can be beneficial for primary school and high school groups.

In this study, the applications conducted in 2009-2010 spring semester are limited to 12 weeks. Content based critical thinking education approach was adopted in critical thinking education. Critical thinking skills were integrated into force-motion and electric-magnetism topics of ninth grade physics course program. These skills can be integrated into different topics on different class grades. Permanency can be investigated in future studies.

Different from other researches in literature, this study aimed to investigate the effects of physics course based on out-of-school learning activities and critical thinking on students' critical thinking disposition and attitudes towards the course. It is thought the results is important in order to indicate the effects of physics course supported with out-of-school learning activities and physics course based on critical thinking when the courses is implemented singly and mutual. Future researches would be conducted in the subject of out-of-school learning activities and critical thinking could be beneficial for comparing the results obtained from this study.

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Appendix 1. *Organization Chart of the Content Based Critical Thinking Education*