A Path Analytic Study: Effect of Affective Characteristics on Learning Outcomes[*]

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Abstract

Primary purpose of this study is to examine affective characteristics affecting the student's achievement and influences of the relationships between these characteristics on the achievement with path analysis. With this purpose, students' self efficacy perceptions and their attitudes towards physics and computer were taken in account as affective characteristics. Each of these characteristics is independent variables and their effects examining on the basis of learning approaches of Computer Aided Cooperative Learning (CACL) and Computer Aided 7E model (CA7E). As a result of these examinations, conducted with the path analysis; it has been determined that the affective characteristics such as attitudes towards the computer and physics courses and self-efficacy perceptions are not an effective factor on the students' achievements considering both in the concept and physics course. Setting out from these findings, it has been concluded that the self-efficacy perception and attitude towards the physics course may not have that much big of an influence on achievement as it has been stated in literature.

Keywords: Field education, path analysis, affective characteristics, achievement

Introduction

The physics course is known as a hard lesson to be successful in by quite many students. The first step in solving a problem is to determine the factors lying beneath at the root of this problem. Therefore, the factors affecting the students' achievements in physics course carry a capital importance. These factors can be both the cognitive and affective. Many numbers of studies examining the relationship of the affective characteristics with achievement have been conducted in text; although not quite enough, important level of information has been collected concerning this area. Certain studies conducted have shown that the affective characteristics are related to the achievement (Gönen and Kocakaya, 2005; Gönen and Kocakaya, 2006; Gönen, Kocakaya and İnan, 2006; Gönen and Kocakaya, 2008). Nevertheless, measure of effectiveness of the affective characteristics in explaining the achievement is not clear yet.

Behind recent increase in the studies in which the affective characteristics' effects on the achievement are analyzed is the thought that results of the students' attitudes towards course effects (selection of occupation, utilization of spear time, the achievement in lesson, etc.) concerning with learning (Koballa, 1988). Current researches show that the students'

attitudes towards the school and courses are important variables affecting the students' achievement in the school (Bloom, 1976; Aşkar and Erdem, 1987 and Koballa, 1988).

Schibeci (1983) has two different opinions towards importance of the affective area. The first one of these is the degree of connection between the affective characteristics and achievement making them too close to one another so much so that they may not be considered different from one another and necessity for the people interested in the students' cognitive achievement to also keep in mind the affective factors. However, in meta-analysis study conducted by Wilson (1983) as a completely opposite opinion to that, he accentuates on the fact that correlation between the attitude and achievement in sciences is not a strong one. It is necessary to assume that the affective characteristics are only formed of the attitude towards course in order to this idea shall be accepted.

The second idea towards the importance of the affective area on the other hand is that control of the affective factors in the educational targets being more important than the control of the cognitive factors. Payne (1977) has concentrated on this second opinion and stated that the affective factors are still at least as important as cognitive factors, if not more important than them. In addition to Payne, as a result of in-depth analyses they have performed; Osborne, Simon and Collins (2003) have informed that the affective components in the education must be handled with a greater importance in the science education. The importance of this subject is also stressed by researchers who have confirmed that the students in many countries are not finding the science very close to themselves (Mattern & Schau, 2002; McGinnis et al., 2002).

The studies on affective factors in the physics education literature are not at an adequate level with regards to their qualities and quantities. For example, while some researchers (Alsop and Watts, 2003; Simpson, Koballa, Oliver and Crawley, 1994) are tackling only the attitude, motivation, belief and interests, certain others (Alsop and Watts, 2003) are also putting the self-confidence addition of these factors have mentioned above. In addition to this, it is also being seen that there is a tendency to incline towards the studies in which the affective variables are analyzed together in the field of education for the last ten years.

Britner and Pajares (2001) have examined in their studies whether or not the science motivation beliefs of the students in middle school have changed as a function of their gender and ethnic backgrounds and further examined whether the science self- efficacy perceptions have been effective in estimating their science achievements. The study has been conducted over 262 students and it has been reported that on the basis of gender, the self-efficacy perceptions towards the science course of the girls have been high as parallel to these characteristics that they have reached to advanced levels in the science, too; boys on the other hand have acquired high performance in order to reach their goals. On the basis of the ethnic background, it has been reported that white students have had high self-efficacy perception and their achievements have had also been high and African-American students on the other hand have had high assignment targets. They have confirmed that the self-efficacy perceptions in estimating the science achievement scores of the students has been the single motivating variable in girls, boys and white students and the self-efficacy in estimating the science achievements scores of the students have been the single motivating variable in African − American students on the other hand has been the only variable.

Zeeger (2004) has examined in his study the factors affecting the student's achievement such as age, gender, preference order of the department in which he/she is attending an education, holding a part-time or full-time position in any workplace, attitude and self-efficacy perceptions with the path analysis. With this purpose, Zeeger has worked with two groups of students in Flinders University and 194 of these students have been freshmen and

118 of them have been sophomores attending an education in the science department. As a result of this study he has stated that the students' achievements have carried from the previous educations that they have received increasing their achievements in the university and their English learning skills. He has reported that there has been no direct correlation between being aware of their cognitive skills (meta-cognitive), self-efficacy perceptions with their academic achievements.

Robbins at al. (2004) has examined the relationship between psychosocial and study skills and the college outcomes in one of their meta-analysis studies. At the end of the study that have conducted in two separate colleges; they have reported that the academic self-efficacy and achievement motivations are the best predictors for the GPA (Cumulative Grade Point Average).

Valentine, DuBois and Cooper (2004) have examined 55 separate studies and examined the relationship between self beliefs, self efficacy, self-concept and self-esteem of the students and later academic achievements with the meta-analysis and stated that magnitude of this relationship has been very weak and the effect of the self-efficacy on the achievement on the other hand has been at a medium level. Güngor, Eryılmaz and Fakioğlu (2007) have analyzed the effects of the affective characteristics on the physics achievement of the students who are freshmen studying the physics with the structural equation model and at the end of their study, the effects of the students' attitudes towards the physics course over the students' achievement have not been found to have a statistically significant effect.

When these studies are examined on the other hand, it is seen that the interaction between the achievement and the affective characteristics are tackled in a fashion in order to cover the direct effects yet the other unobservable effects [IE (Indirect Effect), S (Spurious effect) and U (Unobserved effect)] have not been analyzed. Due to the importance of the subject, the attitudes towards the physics and computer, and self-efficacy perception take place under separate captions.

Physics Attitude

In the studies that have been conducted concerning with the attitude towards the physics; while Redford, 1976; Tamir, Arzi and Zloto, 1974; Maskan and Güler, 2004; Gönen and Kocakaya, 2006; Gönen, Kocakaya and İnan, 2006; Gönen and Kocakaya, 2008 have examined the attitude effects towards the physics on the students' achievement in the physics course in a detailed manner; Tamir et al. 1974 have only made emphasis on the factors influencing the attitude towards the physics. Redford (1976) on the other hand has analyzed the school principles' attitudes, guidance advisors and physics teachers towards the physics in the high school curriculum. In addition to these, Germann (1988), Hough and Piper (1982) and TIMSS (Third International Mathematics and Science Study) (1999) have researched the achievement relationship in the science course with the attitude towards the science and have reached the conclusion that there is a positive relationship between the students' attitudes and their achievements. Additionally, Schibeci and Riley (1986) have tested two different models in forms searching for an answer to the question does the attitude effects on the achievement or is it vice versa and reached to the conclusion for the attitude effects achievement. However, while together with highlighting that there is a correlation like a relationship between the attitude and achievement in their study, Oliver and Simpson (1988) have also pointed out that this relationship explained the large proportion of the variance; Weinburgh (1995) has confirmed that this relationship between the attitude and achievement has been in the positive direction however, it has not been at a high level.

Wilson (1983), in the meta-analysis, has conducted on the students in different educational levels, starting from elementary school continuing on towards the college, and has

examined the relationship between the attitude towards the science and achievement in the science and   between the attitude towards the science and achievement in the science is 0.16 and as the students' education levels have increased, the attitudes have also increased. He has also indicated that the direction of the correlation between the attitude and achievement on the other hand have been higher correlated in the attitude' direction influencing the achievement. Weinburg (1995), in the meta-analysis, has concluded that the relationship between the attitude towards the science and achievement in the science is generally at a medium level and when a comparison is made between the girls and boys, the boys have had more positive attitudes compared to the girls. Third International Mathematics and Science Study (TIMMS), which is much more in-depth, has researched the attitudes of the 8th grade students in 38 countries towards the physics, chemistry and biology, which are sub branches of the science course (Martin et al., 2000). The science attitudes, according to the results of the TIMMS (1999), have been examined in form of two sub categories as usefulness of the science and enjoyment of the science and it has been stated that there is a very clear and positive association between the attitude towards the science and attitudes towards the sub branches of the science. In addition to this, it has been established that the students' attitudes towards these sub branches in countries where the science course is separated into the sub branches as physics, chemistry and biology are lower than the students' attitudes in the countries where the science course is programmed as a whole and not divided into the sub branches.

Physics Self-efficacy

Another important affective characteristic influencing the achievement in educational environment is the self-efficacy. The self-efficacy is an important concept, which is prominent in the Social Learning Theory (Social Cognitive Theory) of Bandura and it is the self-judgments of the individuals who have been concerning how well they would perform the acts which are necessary to cope with the probable circumstances (1977, 1982 and 1995). Bandura has defined self-efficacy as one's belief in one's ability to succeed in specific situations. Gibson and Dembo (1984) have stated that in case the individuals believing that they shall not be able to perform certain activities, they shall either never perform the necessary behavior or that even if they perform that behavior, the behavior shall not remain constant.

Bandura (1995) has stated that there are four main resources of the self-efficacy and these are; absolute and precise experiences, indirect lives provided by social models, verbal persuasion and physical and emotion condition of the individual. The most effective of these resources is the personal experiences of the individual. The beliefs of the self-efficacy affect the goals that the people set for themselves, how much effort they shall put in order to reach these goals, how long they shall face the difficulties they have been encountering in reaching these goals and their reactions against failure. Together with not having many extensive studies that tackle the self-efficacy perception per se; the studies performed have been conducted over lower classes with low achievement level (Schunk, 1994; Schunk & Pajares, 2002). The studies that have been concerning the self-efficacy up to today have shown that the self-efficacy increases as the grade level goes up. Shell, Colvin and Bruning (1995) have determined that the self-efficacy of the 4th grade students have been lower than the 7th grade students and the self-efficacy of the 7th grade students have been lower than the 10th grade students for reading and writing (see Zimmerman & Martinez-Pons, 1990, for similar findings).

The studies that have been performed in the field of education concerning the self-efficacy beliefs are generally handled in three categories. These are the researches associated with the effects of the self-efficacy beliefs on the academic achievement and performance,

researches addressing the effects of the self-efficacy beliefs to area selection of expertise and preferences as occupation and topics and finally the researches addressing the self-efficacy beliefs of the teachers and applications that have been actualized in the education and the relation between different student products as topic (Pajares, 1997). Multon, Brown and Lent (1991) have examined the relationship between the self-efficacy perception and academic products in a meta-analysis and found that this relationship is higher in students who are at high school and university levels rather than according to the elementary school students. Furthermore, they reach to a conclusion that the self-efficacy perception explains the 14% of the variance of the academic performance.

In this study, analyzing the affective characteristics that have been analyzed alone in the science education as an attitude towards the physics and physics' self-efficacy together, it has been considered to be the most suitable characteristics in serving the purpose of study and have been included in the study's variables. Also, due to the fact that the study is executed by receiving assistance from a computer, the students' attitudes towards the computer has also been handled as a variable and these variables' effects, both directly and over one another, to the students' achievements in the physics course have been analyzed by using the path analysis technique, which is an application area of the structural equation model.

Problem status

Results and interpretations that shall be obtained by considering unobservable effects, of which the affective characteristics make over one another affecting the student' achievement instead of a single variable (e.g. teaching method) while the student's achievement is being measured in the studies of field education shall contribute for us to present lasting solutions. While the affective characteristics' effects on the achievement have been examined, the affective characteristics and achievement correlation have generally remained limited with the correlation and regression relationship in the majority of the studies in the educational field and on the studies in which the path analysis is used, and the analysis is made by mostly taking into consideration direct effects (DE). Differently from all other studies that have been conducted until today, the other interaction types (IE, U and S effects) between the variables together with the direct effects have also been taken into account while examining all the factors forming total relation in this study.

Purpose

The primary purpose of this study is to examine the factors affecting the student's achievement with the path analysis technique not only on the basis of teaching method but also considering the other factors (the attitudes towards the physics course and self-efficacy perception with the attitude towards the computer), which may affect the achievement at the same time.

Methodology

Population and Sample

High school students who are taking physics course in the city center of Diyarbakır in Turkey in the academic year of 2006-2007 form the population of this study and 167 students taking physics course in schools where the application is performed in the scope of the study form the sample of this study.

Application Process

Study has been conducted for the duration of 4 weeks (8 hours) over the 167 students who are taking physics course in the 2nd and 3rd grade of four different high schools found in

the city center of the province of Diyarbakır in Turkey in the academic year of 2006-2007. In the scope of the study, the school in which the study is going to be executed determined in the form of one science high school (takes students with central exam), one Anatolian high school (takes students with central exam), one vocational high school and one public high school. Two groups have been formed in each of the schools determined. An electrostatic achievement test (developed by authors) made of 30 multiple choice questions, an electrostatic concept test made of 33 propositions obtained from URL-1 and URL-2 (Retrieved: 2006) and formed from the misconceptions existing in the physics students concerned with the electrostatic subjects worldwide and offered to students in form of two choices of wrong-right by the researcher were used on each of the group formed. In addition to these two tests, a physics attitude scale made of 24 propositions developed by Özyürek and Eryılmaz (2001) (by changing the "indecisive" proposition in form of "partially agree"), a self-efficacy perception towards the physics course made of 5 point Likert type 11 propositions developed by Maskan (2006) and a computer attitude scale made of 5 point Likert type 42 propositions developed by Deniz (1995) were used on each of the group formed. Cronbach-alpha values determined for the scales used respectively: 0.896 for electrostatic achievement test, 0.670 for electrostatic concept test, 0.943 for physics attitude scale, 0.800 for self-efficacy perception scale and 0.923 for computer attitude scale.

Selection of which method of teaching is going to be applied to which group has been made randomly. Teaching was administered to one of the chosen groups according to the CACL (Computer Aided Cooperative Learning) model and the other according to the CA7E (Computer Aided 7E) model. Students taking the physics course according to CACL were divided into sub groups of 3-4 people among themselves. Heterogeneous sub groups were formed in classes that the CACL method was applied by taking into consideration the pre-test scores that the students taken and the opinions of the course teachers. Students taking the course according to the CA7E, lessons were instructed by taking into consideration of the 7E model of the constructive learning approach.

Questions inside the achievement test were grouped as knowledge, comprehension and application levels of the cognitive domain according to the Bloom taxonomy. Eight of the questions that took place in the test took their position on the level of knowledge and 15 of the questions took their position on the level of comprehension and the 7 of the questions took their position on the application level. The reliability coefficient of the test has been determined with the method of dividing the test of Spearman-Brown into two halves of the equal value. Split-half reliability estimates especially useful when "it is impractical or undesirable to assess reliability with two tests or to have test administrations" (Cohen and Swerdlick, 2002, p.133).

Data in this study conducted according to the method of pre-test- post-test were analyzed with the SPSS 15.0 and Amos 7.0 package program. Whether the data obtained been significant or not has been evaluated at the 0.05 significance level. Total scores taken by the students have been calculated by appointing the score of "1" to the each correct answer and appointing the score of "0" to the each wrong answer that the students gave to the questions inside the achievement test. Also the students were told not to place any marks next to the questions that they had no opinions on what their answers might be. Due to the fact that a score of "1" is appointed to the each correct answer in the achievement test, the highest score that a student may take in the test is as high as the number of questions found in the test.

While a scoring method of increasing from 1 to 5 was being used for the positive propositions in the 5-point Likert type scales a scoring method of decreasing from 5 to 1 has been used in the negative propositions. Propositions for the attitude scale towards the physics course were in form of; "Strongly Disagree, Disagree, Partially Agree, Agree, Strongly

Agree", propositions for the attitude scale towards computer were in form of; "Not At All Agree, Some-What Agree, Agree, Very Much Agree, Totally Agree", propositions for the self-efficacy perception scale towards the physics course were in form of; "Never, Rarely, Sometimes, Most of the Time, Always".

Data in this study conducted has been analyzed by using package program of SPSS 15.0 and Amos 7.0. Path coefficients (standardized regression coefficients) of the values obtained as the result of the analysis performed with the package program of SPSS 15.0 and Amos 7.0 have been shown directly on the path diagram and only the correlation coefficients and results of path analysis have been shown in form of tables.

Interactions Seen Between the Variables and Variables Types

There are four different effects among the variables that have been subjected to the path analysis and these are indicated as observable (direct) effect (DE), unobservable (indirect) effect (IE), Unanalyzed effect (U), and Spurious effect (S).

Observable Effect (DE):

The impact performed by a variable without having another variable in between is called as the observable effect.
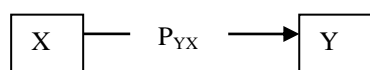

Figure 1. Path Diagram Belonging to the Variables that Show the Observable Effect (DE)

The path coefficient (P_{YX}) that shows the observable effect and the first variable made over the second variable in Figure 1 is equal to the correlation coefficient between two variables.

In other words it is:

$$r_{yx} = P_{YX} \tag{1}$$
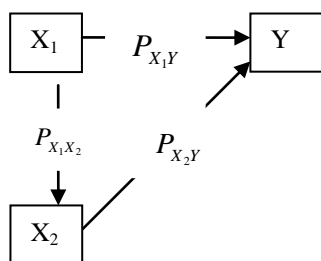
Unobservable Effect (IE):

Figure 2. Path Diagram Belonging to the Variables Showing the Unobservable Effect

The observable effect (P_{X_1Y}) that the X_1 variable in the Figure 2 has had over the Y variable is not equal to the correlation between the variables. The reason for this is that, not only an observable interaction exists between the variables such as in the Figure 2 but there is also an unobservable interaction in question besides that. The total of these effects is equal to the correlation coefficient between the X_1 and Y variables. The observable effect of the X_1 variable in Figure 2 over the Y variable is equal to the path coefficient (P_{X_1Y}) between these two variables. The unobservable effect that the X_1 variable has made over the Y variable on the other hand is equal to product of the path coefficient (P_{X_2Y}) which shows the observable effect that the X_2 variable has made over the Y variable and path coefficient ($P_{X_1X_2}$) by showing the observable effect that the X_1 variable has made over the X_2 variable [IE = ($P_{X_1X_2}$).(P_{X_2Y})]. From here, the total of the observable and unobservable effect is going to be in this form.

$$r_{yx_1} = \text{DE+IE} \tag{2}$$

$$= P_{X_1Y} + P_{X_1X_2} . P_{X_2Y} \tag{3}$$
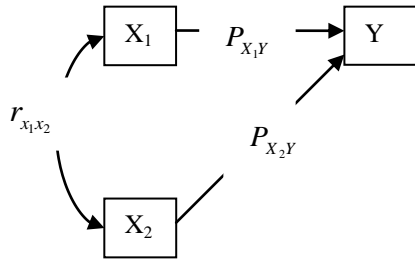
U (Unanalyzed) Effect:

Figure 3 Path Diagram Belonging to the Variables Showing U Effect

When there is a mutual interaction in question among the reason variables, the effect that formed is called the U effect. When the interaction between the X_1 and Y variables in the Figure 3 is examined, it is seen that it has a U effect since there is both an observable effect found over the Y variable by the X_1 variable and a mutual interaction between the X_1 variable and X_2 variable. The observable effect that the X_1 variable has made over the Y variable in Figure 3 is equal to the path coefficient between these variables (DE= P_{X_1Y}). The U effect that the X_1 variable has not made over the X_2 variable on the other hand is equal to the product of the path coefficient that shows the observable effect, which the X_2 variable has made on to the Y variable and correlation coefficient between the variables of X_1 and X_2 variables (UE = $r_{x_1x_2}$. P_{X_2Y}).

These effects' total is equal to the correlation between the X_1 and Y variable.

$$r_{yx_1} = \text{DE+UE} \tag{4}$$

$$= P_{X_1Y} + r_{x_1x_2} . P_{X_2Y} \tag{5}$$

The same condition is also observed when the interaction between the X_2 variable and Y variable is examined.

$$r_{yx_2} = \text{DE+UE} \qquad (6)$$

$$= P_{X_2Y} + r_{x_1x_2} \cdot P_{X_1Y} \qquad (7)$$

S (Spurious) Effect:

The effect that has been seen in the existence of a mutual reason variable, which is affecting both of the variables, we are examining the relationship that is called the S effect. The X_1 variable located in the Figure 4 effects the Y variable in two forms. The first one of them is the observable effect that the X_1 variable does onto the Y variable and the second of them on the other hand is the S effect originating from the existence of a mutual reason variable that is affecting both the X_1 and the Y variable.
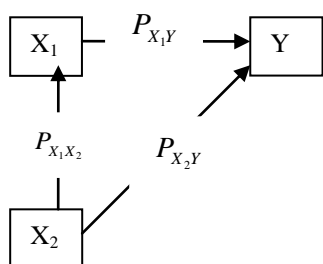

Figure 4 Path Diagram Belonging to the Variables Showing S Effect.

The observable effect of the X_1 variable in the Figure 4 on the Y variable is equal to the path coefficient between the variables (DE $= P_{X_1Y}$). The S effect of the X_1 variable on the Y variable on the other hand is equal to the product of the path coefficient (P_{X_2Y}) showing the observable effect that the X_2 variable has had on to the Y variable and path coefficient ($P_{X_1X_2}$) showing the observable effect of the X_2 variable that has had over the X_1 variable (SE $= P_{X_2Y} \cdot P_{X_1X_2}$). These effects total is equal to the correlation coefficient between the X_1 variable and the Y variable.

$$r_{yx_1} = \text{DE+SE} \qquad (8)$$

$$= P_{X_1Y} + P_{X_2Y} \cdot P_{X_1X_2} \qquad (9)$$

In the path analysis, the variable that has not been affected by any of the variables in the model that has been called as the external variable and the variable that gets affected by at least one of the variables in the model on the other hand is called internal variable. In this case, the X_2 variable found in the Figure 4 is the external variable and the X_1 and Y variables on the other hand are the internal variables.

Interpretation and Analysis of the Data

The data obtained from this study have been tackled on the basis of two learning approaches (CACL and CA7E) and two different path analyses have been performed for the examined affective characteristics' effects for the student achievement. Therefore, besides the affective characteristics' effect, the effectiveness level of the teaching approaches has also been researched.

In the path analysis, in order for the relationships to be fully analyzed; it is necessary to keep in mind all the reason variables and result variables and all the relationships of the

reason variables among themselves and even the existence of a significant relationship between the variables. In order to the interpretation of all conditions creating difference on the result variables and rising from the applied learning approaches together with the affective characteristics and the statistical results as a whole here a different method named "Consistency Coefficient [T(X_m:Y_n)]" has been suggested and a different route of evaluation has been taken. The fundamental steps of this evaluation method which has been suggested by Kocakaya (2008) are as follow:

1. Consistencies in the relationships that the same variables had with one another in each of the two teaching methods have been considered (For example: the gender variable in the CACL and CA7E.).

2. If the relationship between two of the same variables analyzed in each two of the learning approaches and result variable is statistically significant, the consistency coefficient has been accepted as "1".

3. If the relationship between the result variable and only one of two of the same variables analyzed in each two of the learning approaches is statistically significant, the consistency coefficient has been accepted as "0.5".

4. If there is no statistical significance between the result variable and the two of the same variables analyzed in each two of the learning approaches, the consistency coefficient has been accepted as "0".

5. The variables effect with the consistency coefficient of "1" on the result variable has been accepted as directly significant.

6. The variables with the consistency coefficient of "0.5" have been interpreted by looking at the percentage in the total effect of the DE effects of their both.

7. The variables with the consistency coefficient of "0" have been accepted as having no effect on the result variable.

[T(X_m:Y_n); m, n=1, 2, 3….]: has been defined as the consistency coefficient between the X reason variable and Y result variable.

Assumptions

- It has been assumed that the students in the scope of the study have reflected their actual abilities, feelings and opinions in a sincere manner while marking the questions in the achievement test, suggestions in the concept test, suggestion in the self-efficacy perception scale towards the physics course, suggestions in the attitude scale towards the computer,

- It has been assumed that the students of the both groups have had equal interests towards learning,

- It has also been assumed that the variables that may not be controlled have had the same effect rate over the students in both groups.

Restrictions

- This research is limited to the four high schools providing an educational service in the center of the province of Diyarbakır in Turkey and students, who have been attending an education in these schools,

- The physics course, electrostatic subject and with its subheadings,

- The behaviors that have been aimed for in the physics program of Ministry of Education Department,

- And applied tests and scales.

Findings

At the end of the study, it has been determined from the results obtained from the paired-samples t-tests of the groups in order to determine the effect of the learning approach on the student achievement; both CACL (t=6,172 and P<0.001) and CA7E (t=6,852 and P<0.001) contributed positively and significantly to the achievement of the students.

The path diagram showing the relationships between the variables used during the analysis of the data has been given in Figure 5 P_{XY} among the symbols taking place in the Figure 5 shows the path coefficient between the variables and r_{xy} on the other hand shows the correlation coefficient between the variables.
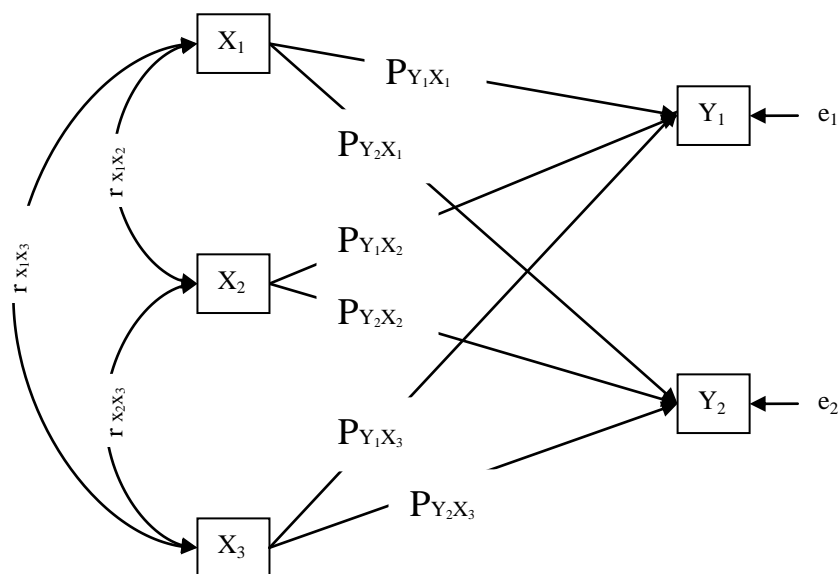

Figure 5. Path Diagram for Attitudes and Self-efficacy Perception

X_1 : Score obtained from computer attitude scale (post-test score)
X_2 : Score obtained from physics attitude scale (post-test score)
X_3 : Score obtained from physics self-efficacy scale (post-test score)
Y_1 : Score obtained from concept test (achievement score)
Y_2 : Score obtained from achievement test (achievement score)
e_1 and e_2 : Unobservable exogenous variables

At the end of the regression analysis performed the path coefficients (standardized regression coefficients) between all the variables have been shown in the diagram in Figure 6 the values on the arrows located in the diagram; the ones on the left side shows the path coefficients obtained from the data of the students that taken physics course with CACL and the ones on the right side shows the path coefficients obtained from the data of the students taken physics course with CA7E (For example; such as 111 & 222).

Since the main purpose of the path analysis is to separate the components of the correlation between the variables, it is necessary for us to know the correlation coefficient between all the variable pairs. Correlation coefficients between all the variables inside the study have been given in Table 1. In the correlation coefficients found in Table 1 there are 2 columns for each variable. Left column shows the correlation coefficients found according to the data of the students taken physics course with CACL and right column shown the correlation coefficient obtained from the data of the students taken physics course with CA7E.

Table 1. Correlation Coefficients Between the Variables Belonging to the Students Taken Physics Course with CACL & CA7E.

Variables		X_1		X_2		X_3	
		CACL	CA7E	CACL	CA7E	CACL	CA7E
X_1	Pearson Corr.	1	1				
	Sig. (2-tailed)						
	N	90	77				
X_2	Pearson Corr.	0,152	0,391**	1	1		
	Sig. (2-tailed)	0,151	0,001				
	N	90	77	90	77		
X_3	Pearson Corr.	0,219*	0,437**	0,665**	0,639**	1	1
	Sig. (2-tailed)	0,038	0,001	0,001	0,001		
	N	90	77	90	77	90	77
Y_1	Pearson Corr.	-0,184	0,105	0,124	-0,030	0,080	0,077
	Sig. (2-tailed)	0,083	0,363	0,242	0,797	0,456	0,506
	N	90	77	90	77	90	77
Y_2	Pearson Corr.	0,144	-0,014	0,312**	0,111	0,371**	-0,088
	Sig. (2-tailed)	0,176	0,904	0,003	0,338	0,001	0,448
	N	90	77	90	77	90	77

*P< 0,05, **P<0,01

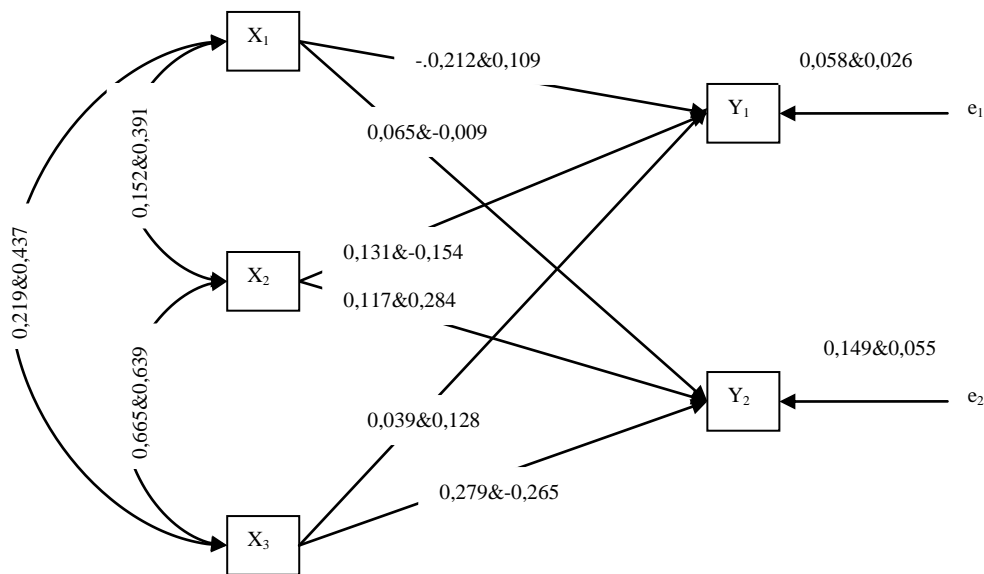**Figure 6.** Path Diagram and Coefficients of the Model Established for the CACL & CA7E Approaches

Separation of the Correlations between the Affective Variables Affecting the Physics Achievement into Components in the Path Model Established for the CACL Approach

In this section, analyses related to affective characteristics which affect achievement of students' physics concept and physics achievement have been given.

Analyses Concerning with the Effects of the Affective Characteristics to the Physics Concept Achievement in the CACL

When the correlations between the variables are separated into components and if the correlation between the X_1 and Y_1 ($r_{y_1 x_1}$) is written by separating the components as it is seen below [for detailed explanation about constructing determinant and linear equations please look at Kocakaya (2008)],

$$r_{y_1 x_1} = \begin{bmatrix} P_{Y_1 X_1} P_{Y_1 X_2} P_{Y_1 X_3} \end{bmatrix} \begin{bmatrix} r_{x_1 x_1} \\ r_{x_2 x_1} \\ r_{x_3 x_1} \end{bmatrix} \tag{10}$$

$$r_{y_1 x_1} = P_{Y_1 X_1} r_{x_1 x_1} + P_{Y_1 X_2} r_{x_2 x_1} + P_{Y_1 X_3} r_{x_3 x_1} \tag{11}$$

It is found such as shown.

In order to this equation to be written in a clear form, it is necessary to state the expansions of the $r_{x_1 x_1}$, $r_{x_2 x_1}$, and $r_{x_3 x_1}$. Since the $r_{x_1 x_1}$, $r_{x_2 x_1}$, and $r_{x_3 x_1}$ are the correlations between the exogenous variables, their values given in the Table 1 is used exactly.

($r_{x_1 x_2} = r_{x_2 x_1}$, $r_{x_1 x_3} = r_{x_3 x_1}$, $r_{x_2 x_3} = r_{x_3 x_2}$)

When the correlation between the X_1 and Y_1 is separated into its components,

$$r_{y_1 x_1} = P_{Y_1 X_1} r_{x_1 x_1} + P_{Y_1 X_2} r_{x_2 x_1} + P_{Y_1 X_3} r_{x_3 x_1} \tag{12}$$

$$r_{y_1 x_1} = -0,184 \tag{13}$$

It is found as shown.

In the analysis above, all the effects of the X_1 over the Y_1 has been shown in Table 2.

Table 2. DE, IE, S and U Effects of the Score Obtained from Computer Attitude Scale on the Score Obtained from the Physics Concept Test

P_{ij}	Form of Effect	Magnitude	Percentage (%)
$P_{Y_1 X_1} r_{x_1 x_1}$	DE	-0,212	115
$P_{Y_1 X_2} r_{x_2 x_1}$	U	0,020	-11
$P_{Y_1 X_3} r_{x_3 x_1}$	U	0,008	-4
Total	$r_{y_1 x_1}$	-0,184	100

When the correlations between the variables are separated into components and if the correlation between the X_2 and Y_1 ($r_{y_1 x_2}$) is written by separating the components as it is seen below,

$$r_{y_1 x_2} = \begin{bmatrix} P_{Y_1 X_1} P_{Y_1 X_2} P_{Y_1 X_3} \end{bmatrix} \begin{bmatrix} r_{x_1 x_2} \\ r_{x_2 x_2} \\ r_{x_3 x_2} \end{bmatrix} \tag{14}$$

$$r_{y_1 x_2} = P_{Y_1 X_1} r_{x_1 x_2} + P_{Y_1 X_2} r_{x_2 x_2} + P_{Y_1 X_3} r_{x_3 x_2} \tag{15}$$

It is found such as shown.

In order to this equation to be written in a clear form, it is necessary to state the expansions of the $r_{x_1 x_1}$, $r_{x_2 x_1}$, and $r_{x_3 x_1}$. Since the $r_{x_1 x_1}$, $r_{x_2 x_1}$, and $r_{x_3 x_1}$ are the correlations between the exogenous variables, their values given in the Table 1 is used exactly.

When the correlation between the X_2 and Y_1 is separated into its components,

$$r_{y_1 x_2} = P_{Y_1 X_1} r_{x_1 x_2} + P_{Y_1 X_2} r_{x_2 x_2} + P_{Y_1 X_3} r_{x_3 x_2} \tag{16}$$

$$r_{y_1 x_2} = 0,124 \tag{17}$$

It is found as shown.

In the analysis above, all the effects of the X_2 over the Y_1 has been shown in Table 3.

Table 3. DE, IE, S and U Effects of the Score Obtained from Physics Attitude Scale on the Score Obtained from the Physics Concept Test

P_{ij}	Form of Effect	Magnitude	Percentage (%)
$P_{Y_1 X_1} r_{x_1 x_2}$	U	-0,032	-26
$P_{Y_1 X_2} r_{x_2 x_2}$	DE	0,131	105
$P_{Y_1 X_3} r_{x_3 x_2}$	U	0,025	21
Total	$r_{y_1 x_2}$	0,124	100

When the correlations between the variables are separated into components and if the correlation between the X_3 and Y_1 ($r_{y_1 x_3}$) is written by separating the components as it is seen below,

$$r_{y_1 x_3} = \begin{bmatrix} P_{Y_1 X_1} & P_{Y_1 X_2} & P_{Y_1 X_3} \end{bmatrix} \begin{bmatrix} r_{x_1 x_3} \\ r_{x_2 x_3} \\ r_{x_3 x_3} \end{bmatrix} \tag{18}$$

$$r_{y_1 x_3} = P_{Y_1 X_1} r_{x_1 x_3} + P_{Y_1 X_2} r_{x_2 x_3} + P_{Y_1 X_3} r_{x_3 x_3} \tag{19}$$

It is found such as shown.

In order to this equation to be written in a clear form, it is necessary to state the expansions of the $r_{x_1 x_1}$, $r_{x_2 x_1}$, and $r_{x_3 x_1}$. Since the $r_{x_1 x_1}$, $r_{x_2 x_1}$, and $r_{x_3 x_1}$ are the correlations between the exogenous variables, their values given in the Table 1 is used exactly.

When the correlation between the X_3 and Y_1 is separated into its components,

$$r_{y_1 x_3} = P_{Y_1 X_1} r_{x_1 x_3} + P_{Y_1 X_2} r_{x_2 x_3} + P_{Y_1 X_3} r_{x_3 x_3} \tag{20}$$

$$r_{y_1 x_3} = 0,080 \tag{21}$$

It is found as shown.

In the analysis above, all the effects of the X_3 over the Y_1 has been shown in Table 4.

Table 4. DE, IE, S and U Effects of the Score Obtained from Physics Self-Efficacy Scale on the Score Obtained from the Physics Concept Test

P_{ij}	Form of Effect	Magnitude	Percentage (%)
$P_{Y_1X_1}r_{x_1x_3}$	U	-0,046	-58
$P_{Y_1X_2}r_{x_2x_3}$	U	0,087	109
$P_{Y_1X_3}r_{x_3x_3}$	DE	0,039	49
Total	$r_{y_1x_3}$	0,080	100

Analyses Concerning with the Effects of the Affective Characteristics to the Physics Achievement in the CACL

When the correlations between the variables are separated into components and if the correlation between the X_1 and Y_2 ($r_{y_2x_1}$) is written by separating the components as it is seen below,

$$r_{y_2x_1} = \begin{bmatrix} P_{Y_2X_1} & P_{Y_2X_2} & P_{Y_2X_3} \end{bmatrix} \begin{bmatrix} r_{x_1x_1} \\ r_{x_2x_1} \\ r_{x_3x_1} \end{bmatrix} \tag{22}$$

$$r_{y_2x_1} = P_{Y_2X_1}r_{x_1x_1} + P_{Y_2X_2}r_{x_2x_1} + P_{Y_2X_3}r_{x_3x_1} \tag{23}$$

It is found such as shown.

In order to this equation to be written in a clear form, it is necessary to state the expansions of the $r_{x_1x_1}$, $r_{x_2x_1}$, and $r_{x_3x_1}$. Since the $r_{x_1x_1}$, $r_{x_2x_1}$, and $r_{x_3x_1}$ are the correlations between the exogenous variables, their values given in the Table 1 is used exactly.

When the correlation between the X_1 and Y_2 is separated into its components,

$$r_{y_2x_1} = P_{Y_2X_1}r_{x_1x_1} + P_{Y_2X_2}r_{x_2x_1} + P_{Y_2X_3}r_{x_3x_1} \tag{24}$$

$$r_{y_2x_1} = 0,144 \tag{25}$$

It is found as shown.

In the analysis above, all the effects of the X_1 over the Y_2 has been shown in Table 5.

Table 5. DE, IE, S and U Effects of the Score Obtained from Computer Attitude Scale on the Score Obtained from the Physics Achievement Test

P_{ij}	Form of Effect	Magnitude	Percentage (%)
$P_{Y_2X_1}r_{x_1x_1}$	DE	0,065	45
$P_{Y_2X_2}r_{x_2x_1}$	U	0,018	12
$P_{Y_2X_3}r_{x_3x_1}$	U	0,061	43
Total	$r_{y_2x_1}$	0,144	100

When the correlations between the variables are separated into components and if the correlation between the X_2 and Y_2 ($r_{y_2x_2}$) is written by separating the components as it is seen below,

$$r_{y_2x_2} = \begin{bmatrix} P_{Y_2X_1} & P_{Y_2X_2} & P_{Y_2X_3} \end{bmatrix} \begin{bmatrix} r_{x_1x_2} \\ r_{x_2x_2} \\ r_{x_3x_2} \end{bmatrix} \tag{26}$$

$$r_{y_2x_2} = P_{Y_2X_1}r_{x_1x_2} + P_{Y_2X_2}r_{x_2x_2} + P_{Y_2X_3}r_{x_3x_2} \tag{27}$$

It is found such as shown.

In order to this equation to be written in a clear form, it is necessary to state the expansions of the $r_{x_1x_1}$, $r_{x_2x_1}$, and $r_{x_3x_1}$. Since the $r_{x_1x_1}$, $r_{x_2x_1}$, and $r_{x_3x_1}$ are the correlations between the exogenous variables, their values given in the Table 1 is used exactly.

When the correlation between the X_2 and Y_2 is separated into its components,

$$r_{y_2x_2} = P_{Y_2X_1}r_{x_1x_2} + P_{Y_2X_2}r_{x_2x_2} + P_{Y_2X_3}r_{x_3x_2} \tag{28}$$

$$r_{y_2x_2} = 0{,}312 \tag{29}$$

It is found as shown.

In the analysis above, all the effects of the X_2 over the Y_2 has been shown in Table 6.

Table 6. DE, IE, S and U Effects of the Score Obtained from Physics Attitude Scale on the Score Obtained from the Physics Achievement Test

P_{ij}	Form of Effect	Magnitude	Percentage(%)
$P_{Y_2X_1}r_{x_1x_2}$	U	0,010	3
$P_{Y_2X_2}r_{x_2x_2}$	DE	0,117	38
$P_{Y_2X_3}r_{x_3x_2}$	U	0,185	59
Total	$r_{y_2x_2}$	0,312	100

When the correlations between the variables are separated into components and if the correlation between the X_3 and Y_2 ($r_{y_2x_3}$) is written by separating the components as it is seen below,

$$r_{y_2x_3} = \begin{bmatrix} P_{Y_2X_1} & P_{Y_2X_2} & P_{Y_2X_3} \end{bmatrix} \begin{bmatrix} r_{x_1x_3} \\ r_{x_2x_3} \\ r_{x_3x_3} \end{bmatrix} \tag{30}$$

$$r_{y_2x_3} = P_{Y_2X_1}r_{x_1x_3} + P_{Y_2X_2}r_{x_2x_3} + P_{Y_2X_3}r_{x_3x_3} \tag{31}$$

It is found such as shown.

In order to this equation to be written in a clear form, it is necessary to state the expansions of the $r_{x_1x_1}$, $r_{x_2x_1}$, and $r_{x_3x_1}$. Since the $r_{x_1x_1}$, $r_{x_2x_1}$, and $r_{x_3x_1}$ are the correlations between the exogenous variables, their values given in the Table 1 is used exactly.

When the correlation between the X_3 and Y_2 is separated into its components,

$$r_{y_2 x_3} = P_{Y_2 X_1} r_{x_1 x_3} + P_{Y_2 X_2} r_{x_2 x_3} + P_{Y_2 X_3} r_{x_3 x_3} \tag{32}$$

$$r_{y_2 x_3} = 0,371 \tag{33}$$

It is found as shown.

In the analysis above, all the effects of the X_3 over the Y_2 has been shown in Table 7.

Table 7. DE, IE, S and U Effects of the Score Obtained from Physics Self-Efficacy Scale on the Score Obtained from the Physics Achievement Test

P_{ij}	Form of Effect	Magnitude	Percentage (%)
$P_{Y_2 X_1} r_{x_1 x_3}$	U	0,014	4
$P_{Y_2 X_2} r_{x_2 x_3}$	U	0,078	21
$P_{Y_2 X_3} r_{x_3 x_3}$	DE	0,279	75
Total	$r_{y_2 x_3}$	0,371	100

When the values of (13), (17), (21), (25), (29) and (33) found as the result of the analyses are compared to the Table 1, it is going to be seen that the result is same with the correlation values given in the table. Since the purpose of the path analysis is to separate the correlation between the variables into components; it is necessary for the total of all components to be equal to the correlation between the variables. For the obtained correlations values which equal with the correlation values given in the tables specified above corresponds one – to – one with the path model we established.

Separation of the Correlations between the Affective Variables Affecting the Physics Achievement into Components in the Path Model Established for the CA7E Approach

In this section, analysis related to affective characteristics which affect achievement of students' physics concept and physics achievement for CA7E Approach had been given.

Analyses Concerning with the Effects of the Affective Characteristics to the Physics Concept Achievement in the CA7E

When the correlations between the variables are separated into components and if the correlation between the X_1 and Y_1 ($r_{y_1 x_1}$) is written by separating the components as it is seen below,

$$r_{y_1 x_1} = \begin{bmatrix} P_{Y_1 X_1} P_{Y_1 X_2} P_{Y_1 X_3} \end{bmatrix} \begin{bmatrix} r_{x_1 x_1} \\ r_{x_2 x_1} \\ r_{x_3 x_1} \end{bmatrix} \tag{34}$$

$$r_{y_1 x_1} = P_{Y_1 X_1} r_{x_1 x_1} + P_{Y_1 X_2} r_{x_2 x_1} + P_{Y_1 X_3} r_{x_3 x_1} \tag{35}$$

It is found such as shown.

In order to this equation to be written in a clear form, it is necessary to state the expansions of the $r_{x_1 x_1}$, $r_{x_2 x_1}$, and $r_{x_3 x_1}$. Since the $r_{x_1 x_1}$, $r_{x_2 x_1}$, and $r_{x_3 x_1}$ are the correlations between the exogenous variables, their values given in the Table 1 is used exactly.

When the correlation between the X_1 and Y_1 is separated into its components,

$$r_{y_1 x_1} = P_{Y_1 X_1} r_{x_1 x_1} + P_{Y_1 X_2} r_{x_2 x_1} + P_{Y_1 X_3} r_{x_3 x_1} \tag{36}$$

$$r_{y_1 x_1} = 0{,}105 \tag{37}$$

It is found as shown.

In the analysis above, all the effects of the X_1 over the Y_1 has been shown in Table 8.

Table 8. DE, IE, S and U Effects of the Score Obtained from Computer Attitude Scale on the Score Obtained from the Physics Concept Test

P_{ij}	Form of Effect	Magnitude	Percentage (%)
$P_{Y_1 X_1} r_{x_1 x_1}$	DE	0,109	104
$P_{Y_1 X_2} r_{x_2 x_1}$	U	- 0,060	-57
$P_{Y_1 X_3} r_{x_3 x_1}$	U	0,056	53
Total	$r_{y_1 x_1}$	0,105	100

When the correlations between the variables are separated into components and if the correlation between the X_2 and Y_1 ($r_{y_1 x_2}$) is written by separating the components as it is seen below,

$$r_{y_1 x_2} = \begin{bmatrix} P_{Y_1 X_1} & P_{Y_1 X_2} & P_{Y_1 X_3} \end{bmatrix} \begin{bmatrix} r_{x_1 x_2} \\ r_{x_2 x_2} \\ r_{x_3 x_2} \end{bmatrix} \tag{38}$$

$$r_{y_1 x_2} = P_{Y_1 X_1} r_{x_1 x_2} + P_{Y_1 X_2} r_{x_2 x_2} + P_{Y_1 X_3} r_{x_3 x_2} \tag{39}$$

It is found such as shown.

In order to this equation to be written in a clear form, it is necessary to state the expansions of the $r_{x_1 x_1}$, $r_{x_2 x_1}$, and $r_{x_3 x_1}$. Since the $r_{x_1 x_1}$, $r_{x_2 x_1}$, and $r_{x_3 x_1}$ are the correlations between the exogenous variables, their values given in the Table 1 is used exactly.

When the correlation between the X_2 and Y_1 is separated into its components,

$$r_{y_1 x_2} = P_{Y_1 X_1} r_{x_1 x_2} + P_{Y_1 X_2} r_{x_2 x_2} + P_{Y_1 X_3} r_{x_3 x_2} \tag{40}$$

$$r_{y_1 x_2} = -0{,}030 \tag{41}$$

It is found as shown.

In the analysis above, all the effects of the X_2 over the Y_1 has been shown in Table 9.

Table 9. DE, IE, S and U Effects of the Score Obtained from Physics Attitude Scale on the Score Obtained from the Physics Concept Test

P_{ij}	Form of Effect	Magnitude	Percentage (%)
$P_{Y_1 X_1} r_{x_1 x_2}$	U	0,043	-144
$P_{Y_1 X_2} r_{x_2 x_2}$	DE	- 0,154	520
$P_{Y_1 X_3} r_{x_3 x_2}$	U	0,081	-276
Total	$r_{y_1 x_2}$	-0,030	100

When the correlations between the variables are separated into components and if the correlation between the X_3 and Y_1 ($r_{y_1 x_3}$) is written by separating the components as it is seen below,

$$r_{y_1 x_3} = \begin{bmatrix} P_{Y_1 X_1} & P_{Y_1 X_2} & P_{Y_1 X_3} \end{bmatrix} \begin{bmatrix} r_{x_1 x_3} \\ r_{x_2 x_3} \\ r_{x_3 x_3} \end{bmatrix} \tag{42}$$

$$r_{y_1 x_3} = P_{Y_1 X_1} r_{x_1 x_3} + P_{Y_1 X_2} r_{x_2 x_3} + P_{Y_1 X_3} r_{x_3 x_3} \tag{43}$$

It is found such as shown.

In order to this equation to be written in a clear form, it is necessary to state the expansions of the $r_{x_1 x_1}$, $r_{x_2 x_1}$, and $r_{x_3 x_1}$. Since the $r_{x_1 x_1}$, $r_{x_2 x_1}$, and $r_{x_3 x_1}$ are the correlations between the exogenous variables, their values given in the Table 1 is used exactly.

When the correlation between the X_3 and Y_1 is separated into its components,

$$r_{y_1 x_3} = P_{Y_1 X_1} r_{x_1 x_3} + P_{Y_1 X_2} r_{x_2 x_3} + P_{Y_1 X_3} r_{x_3 x_3} \tag{44}$$

$$r_{y_1 x_3} = 0,077 \tag{45}$$

It is found as shown.

In the analysis above, all the effects of the X_3 over the Y_1 has been shown in Table 10.

Table 10. DE, IE, S and U Effects of the Score Obtained from Physics Self-Efficacy Scale on the Score Obtained from the Physics Concept Test

P_{ij}	Form of Effect	Magnitude	Percentage (%)
$P_{Y_1 X_1} r_{x_1 x_3}$	U	0,047	61
$P_{Y_1 X_2} r_{x_2 x_3}$	U	- 0,098	-127
$P_{Y_1 X_3} r_{x_3 x_3}$	DE	0,128	166
Total	$r_{y_1 x_3}$	0,077	100

Analyses Concerning with the Effects of the Affective Characteristics to the Physics Achievement in the CA7E

When the correlations between the variables are separated into components and if the correlation between the X_1 and Y_2 ($r_{y_2x_1}$) is written by separating the components as it is seen below,

$$r_{y_2x_1} = \begin{bmatrix} P_{Y_2X_1} & P_{Y_2X_2} & P_{Y_2X_3} \end{bmatrix} \begin{bmatrix} r_{x_1x_1} \\ r_{x_2x_1} \\ r_{x_3x_1} \end{bmatrix} \qquad (46)$$

$$r_{y_2x_1} = P_{Y_2X_1} r_{x_1x_1} + P_{Y_2X_2} r_{x_2x_1} + P_{Y_2X_3} r_{x_3x_1} \qquad (47)$$

It is found such as shown.

In order to this equation to be written in a clear form, it is necessary to state the expansions of the $r_{x_1x_1}$, $r_{x_2x_1}$, and $r_{x_3x_1}$. Since the $r_{x_1x_1}$, $r_{x_2x_1}$, and $r_{x_3x_1}$ are the correlations between the exogenous variables, their values given in the Table 1 is used exactly.

When the correlation between the X_1 and Y_2 is separated into its components,

$$r_{y_2x_1} = P_{Y_2X_1} r_{x_1x_1} + P_{Y_2X_2} r_{x_2x_1} + P_{Y_2X_3} r_{x_3x_1} \qquad (48)$$

$$r_{y_2x_1} = -0,014 \qquad (49)$$

It is found as shown.

In the analysis above, all the effects of the X_1 over the Y_2 has been shown in Table 11.

Table 11. DE, IE, S and U Effects of the Score Obtained from Computer Attitude Scale on the Score Obtained from the Physics Achievement Test

P_{ij}	Form of Effect	Magnitude	Percentage (%)
$P_{Y_2X_1} r_{x_1x_1}$	DE	-0,009	65
$P_{Y_2X_2} r_{x_2x_1}$	U	0,111	-806
$P_{Y_2X_3} r_{x_3x_1}$	U	-0,116	841
Total	$r_{y_2x_1}$	-0,014	100

When the correlations between the variables are separated into components and if the correlation between the X_2 and Y_2 ($r_{y_2x_2}$) is written by separating the components as it is seen below,

$$r_{y_2x_2} = \begin{bmatrix} P_{Y_2X_1} & P_{Y_2X_2} & P_{Y_2X_3} \end{bmatrix} \begin{bmatrix} r_{x_1x_2} \\ r_{x_2x_2} \\ r_{x_3x_2} \end{bmatrix} \qquad (50)$$

$$r_{y_2x_2} = P_{Y_2X_1} r_{x_1x_2} + P_{Y_2X_2} r_{x_2x_2} + P_{Y_2X_3} r_{x_3x_2} \qquad (51)$$

It is found such as shown.

In order to this equation to be written in a clear form, it is necessary to state the expansions of the $r_{x_1x_1}$, $r_{x_2x_1}$, and $r_{x_3x_1}$. Since the $r_{x_1x_1}$, $r_{x_2x_1}$, and $r_{x_3x_1}$ are the correlations between the exogenous variables, their values given in the Table 1 is used exactly.

When the correlation between the X_2 and Y_2 is separated into its components,

$$r_{y_2 x_2} = P_{Y_2 X_1} r_{x_1 x_2} + P_{Y_2 X_2} r_{x_2 x_2} + P_{Y_2 X_3} r_{x_3 x_2} \tag{52}$$

$$r_{y_2 x_2} = 0,111 \tag{53}$$

It is found as shown.

In the analysis above, all the effects of the X_2 over the Y_2 has been shown in Table 12.

Table 12. DE, IE, S and U Effects of the Score Obtained from Physics Attitude Scale on the Score Obtained from the Physics Achievement Test

P_{ij}	Form of Effect	Magnitude	Percentage (%)
$P_{Y_2 X_1} r_{x_1 x_2}$	U	-0,004	-3
$P_{Y_2 X_2} r_{x_2 x_2}$	DE	0,284	255
$P_{Y_2 X_3} r_{x_3 x_2}$	U	- 0,169	-152
Total	$r_{y_2 x_2}$	0,111	100

When the correlations between the variables are separated into components and if the correlation between the X_3 and Y_2 ($r_{y_2 x_3}$) is written by separating the components as it is seen below,

$$r_{y_2 x_3} = \begin{bmatrix} P_{Y_2 X_1} & P_{Y_2 X_2} & P_{Y_2 X_3} \end{bmatrix} \begin{bmatrix} r_{x_1 x_3} \\ r_{x_2 x_3} \\ r_{x_3 x_3} \end{bmatrix} \tag{54}$$

$$r_{y_2 x_3} = P_{Y_2 X_1} r_{x_1 x_3} + P_{Y_2 X_2} r_{x_2 x_3} + P_{Y_2 X_3} r_{x_3 x_3} \tag{55}$$

It is found such as shown.

In order to this equation to be written in a clear form, it is necessary to state the expansions of the $r_{x_1 x_1}$, $r_{x_2 x_1}$, and $r_{x_3 x_1}$. Since the $r_{x_1 x_1}$, $r_{x_2 x_1}$, and $r_{x_3 x_1}$ are the correlations between the exogenous variables, their values given in the Table 1 is used exactly.

When the correlation between the X_3 and Y_2 is separated into its components,

$$r_{y_2 x_3} = P_{Y_2 X_1} r_{x_1 x_3} + P_{Y_2 X_2} r_{x_2 x_3} + P_{Y_2 X_3} r_{x_3 x_3} \tag{56}$$

$$r_{y_2 x_3} = -0,088 \tag{57}$$

It is found as shown.

In the analysis above, all the effects of the X_3 over the Y_2 has been shown in Table 13.

Table 13. DE, IE, S and U Effects of the Score Obtained from Physics Self-Efficacy Scale on the Score Obtained from the Physics Achievement Test

P_{ij}	Form of Effect	Magnitude	Percentage (%)
$P_{Y_2 X_1} r_{x_1 x_3}$	U	-0,004	4
$P_{Y_2 X_2} r_{x_2 x_3}$	U	0,181	-207
$P_{Y_2 X_3} r_{x_3 x_3}$	DE	- 0,265	303
Total	$r_{y_2 x_3}$	-0,088	100

When the values of (37), (41), (45), (49), (53), and (57) found as the result of the analyses are compared to the Table 1, it is going to be seen that the result is same with the correlation values given in the table. Since the purpose of the path analysis is to separate the correlation between the variables into components; it is necessary for the total of all components to be equal to the correlation between the variables. For the obtained correlations values which equal with the correlation values given in the tables specified above corresponds one – to – one with the path model we established.

Discussion

A method not only handling the correlation between these two variables alone but also considering all the variables together, showing the contribution rates of each of these variables to this correlation, having relative results in one respect in the path analysis. The influence contributions of the components forming the correlation have associated with the increase and decreasing numbers of the variables changes (Look at the table from 2 to 13). Only three variables have been handled in this study and together with the variables, the unobservable effects that they apply onto the result variable have been examined. The effects of the other variables (unaddressed or unrealized), which remain on the outside this study' scope on the other hand, have been indicated with a symbol of "e". When looked at the path coefficients of the effects that have been shown with the "e" symbol (Figure 6), it is seen that these values are larger than the path coefficients of some of the variables (Figure 6) that have been discussed in our study. From the findings obtained, it has been realized that the variables outside of the variables that have been used in this study may have significant influences on the result variables, too. It is being considered that the contributions that have been provided into the area of education shall increase by the use of more variables.

The evaluations of the characteristics that have been associated with the cognitive area alone while examining the students' achievement, does not permit to make conclusive judgments on the students' achievements. Therefore, handling the achievements in the affective and psychomotor areas together with the cognitive area of the student shall allow obtaining healthier conclusions in evaluation of the students' achievement. In this study, outside of the cognitive area, the attitudes that the students have had towards the physics and computer courses and the self-efficacy perceptions towards the physics course on the scores that the students have received in the concept and achievement tests that have been examined.

While the data belonging to the students in each of these two groups that have been examined in the first stage, the affective characteristics' effect on the students' achievement has been analyzed in the student groups who have attended an education with CACL and in the second step on the other hand the same processes have been repeated for CA7E. Due to the fact that the table evaluation of the effect for each reason's variable on the result variable

is conducted with the same logic in the path analysis; here an interpretation belonging to only a sample table (Table 7) has been given in a clear fashion as below.

When Table 7 is examined, it is seen that the correlation between the achievement scores that the students have obtained from the achievement test and self-efficacy and perception scores towards the physics course is 0.371 and that it is statistically (P<0.01) significant. According to the value in Table 7, there is a statistically significant correlation in the positive direction between the self-efficacy and perception scores of the students towards the physics course and the scores that the students have received from the achievement test. With a simpler expression, increasing in the self-efficacy perception scores of the students towards the physics course's effects, their achievement is in a positive direction. When this correlation is separated into its components on the other hand (Table 7), the direct effect of the students' self-efficacy perception scores towards the physics course on the students' physics achievements is 0.279 and the contribution of this magnitude in total correlation on the other hand is a value of 75%. There are 2 separate U effects existing which are originating from the relationships of the students' self-efficacy and perceptions towards the physics course and their attitudes towards the computer and physics course. The magnitudes of the other effects and their contribution shares in the total correlation respectively on the other hand are in the form of 0.014 (4%) and 0.078 (21%). As it is also seen in Table 7, the direct effect (DE) of the self-efficacy and the perception towards the physics course over the students' achievements in the physics course forms approximately the three fourths of the total correlation. Also, it has been seen that there is a 21% of a positive effect of the self-efficacy and perception towards the physics course over the attitude towards the physics course and together with this, it has also been seen that the effect made over the attitude towards the computer is on the other hand is at an inconsiderable level next to these effects.

Relationships Found Statistically Significant in Path Analysis

When we examine the relationships between the reason and result variable according to this method that has been suggested by Kocakaya (2008) and when we look at the correlation values in Table 1 for examining the affective variables' effects (X_1: Attitude towards computer, X_2: Attitude towards the physics course, X_3: Self-efficacy and perception towards the physics course) on Y_1 (The concept achievement score of the student concerning the physics' subjects) and Y_2 (The students' physics achievement score in the study); consistency coefficients obtained by following the method that has been suggested above (Section 2.4) are as below;

$T(X_1:Y_1) = 0$
$T(X_2:Y_1) = 0$
$T(X_3:Y_1) = 0$
$T(X_1:Y_2) = 0$
$T(X_2:Y_2) = 0.5$
$T(X_3:Y_2) = 0.5$

It is able to be said that the X_1, X_2 and X_3 reason variables do not have significant effects on the Y_1 result variable, when looking at the values of the $T(X_1:Y_1)$, $T(X_2:Y_1)$ and $T(X_3:Y_1)$ since their consistency coefficients are "0". To simplify, it is able to be said that the students' attitudes towards the computer (Table 2 and Table 8) and physics course (Table 3 and Table 9) and self-efficacy perceptions towards the physics course (Table 4 and Table 10) do not have a significant effect on the students' concept achievements.

When the affective characteristics' effects on the students' physics achievements are examined on the other hand, it has been concluded that the students' attitudes towards the computer has no effect on the physics' achievement of the students since the value of the $T(X_1:Y_2)$ is "0", the X_1 does not have a considerable effect on the Y_2.

Since the consistency coefficients of the $T(X_2:Y_2)$ and $T(X_3:Y_2)$ are "0.5"; we have looked at the DE effects of the X_2 (Table 6 and Table 12) and X_3 (Table 7 and Table 13) on the Y_2 in order to evaluate whether or not the X_2 and X_3 is effective on the Y_2.

For $T(X_2:Y_2)$, it is seen that the DE effect of the X_2 on Y_2 is a percentage of 38% and in size of 0.117 (Table 6). The value here is approximately the one third of the correlation value of the X_2 in significant size of 99% and of 0.312 seen in Table 1. One third of the total effect on the other hand is not considered statistically significant (Table 6). When Table 12 is examined in the same way, even though the DE effect of the X_2 on the Y_2 has a share of 255% and magnitude of 0.284, this effect is not considered to be a significant one due to the fact that the significance level of the correlation between the X_2 and Y_2 is P=0.448. Due to these two reasons mentioned, the interpretation of the X_2 does not have a significant effect on the Y_2 that has been made for the X_2. Simply, it is able to be said that the students' attitudes towards the physics course does not form a significant effect on the students' physics achievements.

For the $T(X_3:Y_2)$, it is seen that the DE effect of the X_3 on the Y_2 is in the proportion of 75% and in magnitude of 0.279 (Table 7). The value here is approximately the three fourths of the correlation value of the X_3 in significant magnitude of 99% and of 0.371 seen in Table 1. This effect which is in three fourths of a size of the total effect on the other hand has been considered statistically significant (Table 7). When the Table 13 is examined in the same way, DE effect of the X_3 on the Y_2 is in the proportion of 303% and in the magnitude of 0.265. Although the DE effect of the X_3 is 3 times larger than the total effect may make it seem to be significant, it is seen that it has a negative effect on the achievement due to the reason that the correlation between them is a negative one. While there is a positive and significant effect in question between the X_3 and Y_2 in Table 7 regarding these variables, there is a significant but negative effect, which is the total opposite, in question in Table 13. Therefore, it has been concluded that there is no positive effect of the X_3 on the Y_2 for the students attending an education with both CACL and CA7E. With a simpler expression, it is able to be said that the students' self-efficacy and perception towards the physics course do not form a significant effect on the students' physics achievement.

Examination of the data obtained in the scope of this study from the different point of view shall ease understanding of the difference between this study and previous studies that have been associated with the affective characteristics. First of all, when we look at the correlation between the affective characteristics and achievement, it is seen that both the attitude towards the physics course and self-efficacy perception have a statistically significant correlation with the achievement. By taking this finding into consideration, we are able to expect an increase in the achievement as parallel to the increase in one of these characteristics that have an effect on the student's achievement. It is stated in literature that both the attitude and self-efficacy perception have high level of relationship with the achievement (Bloom, 1976; Schibeci&Riley, 1986; Shrigley et al., 1988; Talton & Simpson, 1986; Güngör, Eryılmaz & Fakioğlu, 2007) and this also explains the variance in large proportion (Multon, Brown, and Lent, 1991; Robbins et al., 2004). Second of all, when the same affective characteristics' effect on the achievement is examined with the path analysis, even though the relationship with the attitude and self-efficacy perception seem to look at high level and significant, when the correlation between these variables is separated into its components and when the direct effects (DE) of both of these two characteristics on the achievement is evaluated with the method that has been introduced by Kocakaya (2008), and it is not seen to

be significant. In some of the studies examining the affective characteristics' effects on the students' achievement; together with having studies which are reporting that these characteristics are effective (high or medium level) on the achievement (Tschannen-Moran and Woolfolk-Hoy, 2001; Multon, Brown and Lent, 1991; Robbins and friends, 2004; Valentine, DuBois and Cooper 2004), there are some studies found reporting that there are very low or statistically insignificant effects (Zeegers, 2004; Güngor, Eryılmaz and Fakioğlu 2007). When these studies' results are evaluated together, it is being understood, while the interactions between the variables are being examined, that the analyses conducted in one dimension (e.g. only the correlational relationship) shall not bring the researchers to satisfying and strong based conclusions. The interactions between the variables are able to be proven better with the multi-dimensional analysis (for example, path analysis) that has been conducted by considering the effects of many variables together and more extensive.

Conclusion and Suggestions

The affective characteristics' effects have been examined with the path analysis in the study and the conclusions have been reached as below.

When the affective characteristics' effects on the students' achievement are examined as correlation, it has been seen that both the attitude towards the physics and self-efficacy perception towards the physics have had a significant correlation with the achievement. However, when these correlations between these variables are separated into their components with the path analysis; it has seen that there are unobservable effects of variables affecting the result variables via over each others. When the correlation between the cause and effect variables are separated into its components;

- It has been seen that the students' attitudes towards the computer and the physics course and self-efficacy perceptions are not an effective factor in the students' concept achievements,

- The attitude towards the computer does not have any positive contributions to the students' physics achievement when its effects on the students' achievement in the physics course is examined,

- And, it has further been seen that there is also no clear the attitude's effect towards the physics course and self-efficacy perception on the student's achievement.

In light of these findings, the attitude' conclusion towards the physics course and self-efficacy perception may not have very large effects on the achievement that has been made just as it has been stated in the certain literature.

These conclusions show that the only factor increasing the student's achievement in our study is the teaching method.

The other affective characters' effects that have been held outside of the study's scope on the achievement (e. total of all the other unobservable effects) have been found larger than some of the variables' effects that have been tackled in this study, indicating the fact that it is also necessary for these variables to be considered. Therefore, it is being considered that much more consistent results shall be obtained and contributions shall be made into the field of education with a study, which is much more extensive and spread onto longer periods of time and with an analysis performed with more of the affective variables that have been added into the path diagrams both.

References

Alsop, S., &Watts, S. (2003). Science education and affect. *International Journal of Science Education*, 25, 1043–1047.

Aşkar, P. & Erdem, M., (1987) Attitude scale towards teacher job. *Contemporary Education Journal*, 121, 8-11.

Bandura, A. (1995), *Exercise of personal and collective efficacy in changing societies*. In A. Bandura (Ed.), *Self-efficacy in Changing Societies*. (pp. 1-45). New York: Cambridge University Pres.

Bandura, A. (1982), Self-efficacy mechanism in human agency. *American Psychologist*, 37(2), 122-147.

Bandura. A. (1977), Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review,* 84, 191-215.

Bloom, B.S., (1976). *Human Characteristics and School Learning*. New York: McGraw Hill.

Britner, S., L. & Pajares, F., (2001). Self-efficacy beliefs, motivation, race, and gender in middle school science. *Journal of Women and Minorities in Science and Engineering*. 7(4), 1-23.

Deniz, L., (1995). An Attitude Scale towards Computer (in Turkish). Unpublished Doctorate Thesis, Marmara University, Institute of Science, Istanbul, TURKEY.

Germann, P.J. (1988). Development of the attitudes toward science in school assessment and its use to investigate the relationship between science achievement and attitude toward science in school. *Journal of Research in Science Teaching*, 25(8), 689-703.

Gibson, S. & Dembo, M.H. (1984), Teacher efficacy: A construct validation. *Journal of Educational Psychology*, 76(4), 569-582.

Gönen, S. & Kocakaya, S. (2008). Instructional technologies and its effects on affective characteristics. *II. International Computer and Instructional Technologies Symposium*, Ege University, Turkey.

Gönen, S., Kocakaya, S. & İnan, C. (2006) "The effect of the computer assisted teaching and 7e model of the constructivist learning methods on the achievements and attitudes of high school students. *The Turkish Online Journal of Educational Technology*, 5(4), Article 11.

Gönen, S. & Kocakaya, S. (2006). An investigation of the effect of the instruction methods difference on the lycee-i students' physics achievements and computer attitudes based on the gender. *6th International Educational Technology Conference*. Proceedings, Vol.II, 740-754. Eastern Mediterranean University, Famagusta, North Cyprus.

Gönen, S. & Kocakaya, S. (2005). The comparison of physics achievements and computer attitudes of the first year students of a high school according to two different instruction methods. *Pamukkale University Journal of Education Faculty*, 17(1), 14-22.

Güngör, A., Eryılmaz, A. & Fakioğlu, T. (2007). The relationship of freshmen's physics achievement and their related affective characteristics. *Journal of Research in Science Teaching*, 44(8), 1036-1056.

Hough, L.W. & Piper, M.K. (1982). The relationship between attitudes toward science and science achievement. *Journal of Research in Science Teaching*, 19(1), 33-38.

Kobala, T.R., (1988). Attitude and related concepts in science education. *Science Education*, 72(2), 115-126.

Kocakaya, S. (2008). *Analyzing the Relationships between the Factors that Affect the Achievements of Students in Physics Course with the Path Analysis Technique,* (in Turkish) Unpublished Doctorate Thesis, Institute of Science, Dicle University, Turkey.

Martin, M.O., Mullis, I.V.S., Gonzales, E.J., Gregory, K.D., Smith, T.A., Chrostowski, S.J., Garden, R.A. & O'Connor, K.M. (2000). *TIMSS 1999 - International science report: Findings from IEA's repeat of the third international mathematics and science study at the eighth grade*. Retrieved date: April 18, 2012 from http://timss.bc.edu/timss1999i/publications.html

Maskan, A.K. & Güler, G. (2004), Effect of the concept maps on the physics student teachers' electrostatic concept achievement and attitudes towards physics. *Contemporary Education Journal,* 309, 34-41.

Maskan, A. (2006). *An Investigation of Evaluations of Students' Educated at Physics Program Self-efficacy Perceptions towards Physics (in Turkish)*. 7th National Congress of Science and Mathematic Education, Gazi University, Ankara/TURKEY.

Mattern, N. & Schau, C. (2002). Gender differences in science attitude–achievement relationships over time among white middle-school students. *Journal of Research in Science Teaching*, 39, 324–340.

McGinnis, J.R., Kramer, S., Shama, G., Graeber, A., Parker, C. & Watanabe, T. (2002). Undergraduates' attitudes and beliefs of subject matter and pedagogy measured periodically in a reform-based mathematics and science teacher preparation program. *Journal of Research in Science Teaching*, 39, 713–737.

Multon, K.D., Brown, S.D. & Lent, R.W. (1991). Relation of self-efficacy beliefs to academic outcomes: a meta-analytic investigation. *Journal of Counseling Psychology*, 38, 30-38.

Oliver, J.S. & Simpson, R.D. (1988). Influences of attitude toward science, achievement motivation, and science self concept on achievement in science: a longitudinal study. *Science Education*, 72(2), 143-155.

Osborne, J., Simon, S. & Collins, S. (2003). Attitudes towards Science: A review of the literature and its implications. *International Journal of Science Education*, 25, 1049-1079.

Özyürek, A. & Eryılmaz, A. (2001). Factors affecting students' attitudes towards physics. *Education and Science*, 26(120), 21-28.

Pajares, F. (1997), Current directions in self-efficacy research. In M. Maehr & P.R. Pintrich (Eds.), *Advances in Motivation and Achievement*. (Vol.10,p 1-49). Greenwich, CT: JAI Press.

Payne, D.A. (1977). *The Assessment of Learning: Cognitive and Affective.* Lexington, MA: D.C. Heath and Co.

Redford, E.G. (1976). Attitudes toward physics in the high school curriculum. *American Journal of Physics*, 44(4), 337-339.

Robbins, S.B., Lauver, K., Le, H., Davis, D., Langley, R. & Carlstrom, A. (2004). Do psychosocial and study skills factors predict college outcomes? A meta-analysis. *Psychological Bulletin*, 130, 261–288.

Schibeci, R.A. (1983). Selecting appropriate attitudinal objectives for school science. *Science Education*, 67, 595–603.

Schibeci, R.A. & Riley, J.P. (1986). Influence of students' background and perceptions on science attitudes and achievement. *Journal of Research in Science Teaching*, 23, 177-187.

Schunk, D.H. (1994). Self-Regulation of Self-Efficacy and Attributions in Academic Settings. In D.H. Schunk & B.J. Zimmerman (Eds.), *Self-Regulation of Learning and Performance*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Schunk, D.H. & Pajares, F. (2002). The Development of Academic Self-Efficacy. In A. Wigfield & J.S. Eccles (Eds.), *Development of Achievement Motivation* (pp. 15-32). San Diego: Academic Press.

Shell, D.F., Colvin, C. & Bruning, R.H. (1995). Self-efficacy, attribution, and outcome expectancy mechanisms in reading and writing achievement: grade-level and achievement-level differences. *Journal of Educational Psychology*, 87, 386-398.

Shrigley, R.L., Koballa, T.R. & Simpson, R.D. (1988). Defining attitude for science educators. *Journal of Research in Science Teaching*, 25, 659–678.

Simpson, R., Koballa, T., Oliver, J. & Crawley, F. (1994). Research on the Affective Dimensions of Science Learning. In: D. Gabel (Ed.), *Handbook of Research on Science Teaching and Learning* (pp. 211–250). New York: Macmillian.

Talton, E.L. & Simpson, R.D. (1986). Relationships of attitudes toward self, family, and school with attitude toward science among adolescents. *Science Education*, 70, 365–374.

Tamir, P., Arzi, A. & Zloto, D. (1974). Attitudes of Israeli high school students towards physics. *Science Education,* 58(1), 75-86.

Tschannen-Moran, M. & Woolfolk Hoy, A. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education*, 17, 783-805.

TIMSS (1999). "http://www.timss.com" Retrieved date: 15.11.2007.

URL-1., (2006). w3.gazi.edu.tr/~bgunes/files/kavramyanilgilari/fizikte%20sik%20 rastlanilan%20 kavram %20yanilgilari.html Retrieved date: 15.11.2007.

URL-2., (2006). phys.udallas.edu/C3P/Preconceptions.pdf Retrieved date: 15.11.2007.

Valentine, J.C., DuBois, D.L. & Cooper, H. (2004). The relation between self-beliefs and academic achievement: A meta-analytic review. *Educational Psychologist*, 39, 111-133.

Weinburg, M. (1995). Gender differences in student attitudes toward science: a meta-analysis of the literature from 1970 to 1991. *Journal of Research in Science Teaching*, 32, 387-398.

Willson, V.L. (1983). A meta-analysis of the relationship between science achievement and science attitude: Kindergarten through college. *Journal of Research in Science Teaching*, 20, 839–850.

Zeegers P., (2004). Student learning in higher education: A path analysis of academic achievement in science. *Higher Education Research & Development*, 23:1, 35 − 56.

Zimmerman, B.J. & Martinez-Pons, M. (1990). Student differences in delf-regulated learning: Relating grade, sex, and giftedness to self-efficacy and strategy use. *Journal of Educational Psychology,* 82, 51-59.