# Predicting physics achievement: attitude towards physics, self-efficacy of learning physics, and mathematics achievement

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## Contents



## Abstract

This study aims to explore the relationships among Turkish high school students' attitude towards physics, self-efficacy of learning physics, mathematics achievement, and physics achievement. To investigate the relationships, a unique questionnaire that identifies the attitude, self-efficacy and achievements were delivered to a total of 301 high school students. Then a hierarchical regression analysis was performed to reveal the relationships. The results of this study showed that whereas the dimensions ‘comprehension’ and ‘requirement’ in attitude towards physics positively and significantly predicted physics achievement, the dimensions ‘importance’ and ‘interest’ did not. Moreover, self-efficacy of learning physics and mathematics achievement were positive and significant predictors of physics achievement. Mathematics achievement was also the strongest positive predictor of physics achievement and this explained 18.8% of the variance in physics achievement. The students’ physics achievement can be increased by developing their attitudes towards physics and self-efficacy of learning physics as well as increasing their mathematics achievement.

**Keywords**: attitude towards physics, mathematics achievement, physics achievement, regression analysis, self-efficacy of learning physics

# Introduction

Debates still continue on improving students’ science achievement all over the world today. Many of the countries determine their national science education standards and put these standards into their national curricula to increase students’ science achievement (see National Research Council [NRC], 1996). Some science teaching strategies that believed to be more influential in increasing students’ science achievement are also espoused in these curricula. For example, according to NRC (1996) in USA, students’ active involvement in learning science by engaging them with inquiry-based hands-on or laboratory activities is important to develop the students’ science achievement and science process skills. Furthermore, countries compete with each other in some international assessments; one of them is TIMSS that measures students’ science and mathematics achievement. The major criterion to rank the countries’ success is students’ science and mathematics scores in the TIMSS (Mullis & Martin, 2013). It can be claimed that each attempt for improving science education is closely related to students’ science achievement. Considering the science achievement as an important outcome variable, this study aims to explore how Turkish high school students’ attitude towards physics, self-efficacy of learning physics and mathematics achievement predict their physics achievement.

# Theoretical Background

### *Attitude and academic achievement*

Attitude refers to "a predisposition to respond positively or negatively to things, people, places, events or ideas" (Simpson, Koballa, Oliver & Crawley, 1994, p. 212). It is related to some of the psychological constructs such as beliefs (Fishbein & Ajzen, 1975), and perceptions (Bem, 1972). In addition, there is a close relationship between attitude and achievement behaviors (Eccles et al., 1983). Some achievement behaviors (e.g., performance in a course) can be influenced by attitudes. Some dimensions of the attitudes such as importance of any science disciplines, liking or disliking the disciplines, and interest or not interest in the disciplines can be closely related to achievement performances (Eccles et al., 1983).

Furthermore, attitude toward behavior that is affected by behavioral beliefs in the Theory of Planned Behavior can influence behavioral intention of individuals, and then this can affect their behaviors (Ajzen, 1985). Fishbein and Ajzen (1975) claimed that definition of attitude that is "a learned predisposition to respond to an object in a consistently favorable and unfavorable manner" (p. 336) imply a close relationship between attitude and behavior. They also discussed that attitudes are serious predictors of certain behaviors. For example, having positive attitude towards some behaviors can result in some positive specific actions. If someone is able to determine one's attitudes, they can also estimate his/her behaviors as an outcome of these attitudes. There can be a strong relationship between attitude and behavior (Fishbein & Ajzen, 1975). Considering the above discussions it can be assumed that there can also be a close relationship between attitude and students' academic performance or achievement. Under the discussions expecting students to study hard if they have positive attitude towards any subjects or topics to show better academic performance can be reasonable. In the study of Manstead and Van Eekelen (1998), students' performances in the exams were also considered as their behavior under the discussions of Theory of Planned Behavior. As a result, there can be a strong relationship between attitudes and academic achievements as Eccles et al. (1983) indicated.

### *Self-efficacy and academic achievement*

Perceived self-efficacy refers to individuals' beliefs related to their judgments and capabilities to organize the actions for reaching their designated goals (Bandura, 1997). It is closely related to their own motivation and behaviors (Bandura, 1993). This can affect students' motivation to accomplish the tasks given and their attainment of some skills (Schunk, 1984). According to Bandura (1997), self-efficacious students are more motivated to achieve the goals determined, and they work harder. Furthermore, there is a close relationship between self-efficacy and academic achievement (Zimmerman, 2000). Pajares and Schunk (2001) have discussed that having a higher level of efficacy increases individuals' accomplishments. They are more confident in mastering the difficult tasks that they encounter and persist on achieving in these tasks. Therefore, students' confidence about their capability is critical in determining their academic achievement (Pajares & Schunk, 2001).

# Related literature

### *Attitude toward physics and physics achievement*

There were some studies investigating the relationship between learners' attitude towards physics and physics achievement. While some researchers found significant relationship between the two variables, some did not. For example, Papanastasiou and Zembylas (2002) investigated the effect of students' attitude towards science that composed of liking for science disciplines physics, chemistry, biology and earth science on the students' TIMSS science scores. They found that students' positive attitude towards science positively affected their science achievement. Çapri (2013) also found that university students' attitude towards physics lesson predicted their physics achievement. However, this explained only a small portion of the variance in students' academic achievement. Moreover, Chang and Cheng (2008) found that 11th-grade students' physics achievement was positively and significantly correlated with their interest in science.

Differently, significant relationships could not be found between students' attitude towards physics and their physics achievement in some studies (e.g., Gungor, Eryılmaz & Fakıoglu, 2007; Willson, Ackerman and Malave, 2000). The study of Gungor et al. (2007) showed that freshmen physics students' attitude towards physics did not significantly explain their physics achievement. In their study they also found that there were positive relationships between dimensions of attitude towards physics except the dimension 'aspiring extra activities related to physics' and physics achievement. Willson et al. (2000) also investigated the relationships between college freshmen engineering students' attitude toward science and their physics achievement. Their results revealed that there was no significant relationship between them. Consequently, in the literature there are contradictory results in terms of the relationships between physics achievement and attitudes towards physics.

### *Self-efficacy of learning physics and physics achievement*

The relationship between self-efficacy in physics and physics achievement was also explored. For example, some scholars (e.g., Çapri, 2013; Yerdelen-Damar & Peşman, 2013) found close relationships between learners' self-efficacy and their physics achievement. For example, Yerdelen-Damar and Peşman (2013) studied with high school students and they found that students' self-efficacy of learning physics was directly and significantly related to their physics achievement. They also found that 12% of the variance in physics achievement was explained by self-efficacy of learning physics. In this regard, they believed that increase in self-efficacy might result in increase in physics achievement. In a study of Çapri (2013) with university students, it was also found that 15.7% variance of university students' physics achievement was explained by their self-efficacy of learning physics. Marsh et al. (2015) found a positive correlation (r=.300) between students' physics homework self-efficacy and physics achievement. In this study, physics homework self-efficacy measured the capabilities about achieving physics homework. In contrast, Gungor et al. (2007) found that there were slightly negative and insignificant relationship (r=-.004) between freshmen physics students' self-efficacy in physics and their physics achievement. They discussed that the reason of this result might be inconsistencies in students' thoughts. To summarize, in many of the studies (e.g., Marsh et al., 2015; Yerdelen-Damar & Peşman, 2013) self-efficacy in physics was positively related to physics achievement.

### *Physics achievement and mathematics achievement*

Some studies (e.g., Marsh et al., 2015; Veloo, Nor & Khalid, 2015) revealed that learners' physics achievement was closely and positively related to their mathematics achievement. For example, Marsh et al. (2015) compared the relationships among the students' achievements in different disciplines. They found a positive correlation (r=.318) between students' mathematics and physics achievement. Veloo et al. (2015) also found a high and significant correlation (r=.740) between high school students' additional mathematics achievement and physics achievement. Similar to these studies, Jiar and Long (2014) studied with students to investigate the relationships between their mathematical thinking and physics achievement. All the sub-dimensions of mathematical thinking including intellectual skills, verbal information, mathematical attitudes and cognitive strategy were significantly correlated with physics achievement. Furthermore, each of these variables separately, significantly predicted physics achievement. These variables also together explained the 38% of variance in physics achievement.

In his study Meltzer (2002) also studied on the relationships between students' mathematics skills and their learning gains in physics course that was designed considering interactive-engagement methods. He found that the students' learning gains in physics were not correlated with their success in physics concept test but these were significantly correlated with their mathematics preparation. Finally, Eryılmaz and Tatlı (1999) found that there was almost no relationship (r=.02) between pre-service physics teachers' mathematics aptitude and mechanics achievement. However, more recent studies (e.g., Marsh et al., 2015; Veloo et al., 2015) showed that there were high and positive correlations between mathematics achievement and physics achievement. As a conclusion, there can be positive and significant relationship between mathematics achievement and physics achievement as indicated in most of the studies (e.g., Marsh et al., 2015; Meltzer, 2002)

## Significance

The relationships between physics achievement and some physiological variables were investigated. For example, some studies (Çapri, 2013; Papanastasiou & Zembylas, 2002) showed that students' attitudes toward physics were positively related to their physics achievement. Some (Çapri, 2013; Yerdelen-Damar & Peşman, 2013) also revealed that students' physics achievement could be significantly explained by their self-efficacy of learning physics. In addition, students' mathematics achievement was an important factor in determining their physics achievement (Meltzer, 2002). The majority of the studies (e.g., Gungor et al., 2007; Willson et al., 2000) focused on the psychological constructs on predicting students' physics achievement. Some studies (e.g., Marsh et al., 2015; Veloo et al., 2015) also showed the correlations between students' success in mathematics and physics. However, there are a few studies that discuss the role of students' mathematics achievement in explaining their physics achievement considering also psychological constructs. Which ones psychological constructs or mathematics achievements are more effective in explaining physics achievement is still unclear. Identifying the most effective predictors of physics achievement might enable researchers or teachers to focus on these predictors more to be able to increase students' physics achievement. Although regression analyses cannot imply causality (Tabachnick & Fidell, 2007), improving the students' attitude towards physics or mathematics achievement may also result in improved physics achievement in actual learning environments. Due to the most predictive variable of physics achievement to be identified in this study, more importance for the improvement of this predictive variable should be given to increase physics achievement more in learning of physics.

It can also be claimed that students' science achievements in international assessments might be very important criterion to rank the countries education levels as mentioned before. For example, some predictions can be made about the quality of the education in the countries according to the students' scores in these assessments. One of the developing countries Turkey has put some education reforms to compete with developed countries in international assessments. Therefore, there have been radical changes in science curricula in primary and secondary schools for last decade. In the final version of the revised curricula (see Ministry of National Education [MoNE], 2013a, 2013b) in Turkey, students' active involvement in learning science are also emphasized and teachers are advised to perform more science inquiry activities. It is advocated that these could enable students to have some cognitive and psychomotor skills and more positive attitude towards science. Therefore, some significant relationships between psychological constructs (e.g., attitude, belief, motivation) and students' outcomes (e.g., achievement in exams, projects, and experiments) might be expected. Theoretical ideas about the relationship between behavior and attitude (see Eccles et al., 1983; Fishbein & Ajzen, 1975) also support this claim. However, in some of the studies related to physics education (e.g., Gungor et al., 2007; Willson et al., 2000) significant relationships between physics attitude and physics achievement were not observed. With the chancing education systems that emphasize more students' active involvement in science learning all over the world today and also in Turkey there might be some changes in students' attitude towards physics. Thus there also might be significant relationships between attitude towards physics and physics achievement. Investigating whether such a relationship exists can help researchers or teachers to better understand the effectiveness of some reforms in science education on students' science/physics achievement. For example, different strategies or methods that might increase the students' attitudes, self-efficacies and achievements should be advised to the teachers.

# Method

### *Sample*

A total of 301 Turkish high school students (male=143, female=158) participated in this study. Their grades were ranged from 9 to 11. Data were collected from three different high schools in one of the cities that located in Eastern region of Turkey. Purposive sampling was used (Fraenkel & Wallen, 2005). The reason of this is to reach a variety of students with different characteristics. In each school only one classroom for each grade was randomly chosen. While also choosing the schools to be included in the study, students' achievement scores in nationwide exams TEOGs (i.e., the exams that were applied to the students during their elementary education) were taken into consideration. Students are placed in high schools according to their scores in these exams in Turkey. For example, the students who take high scores in the exams have a right to enroll in the schools that composed of mostly high-achieving students. Similarly, the students who take low scores in the exams have a right to enroll in the schools that composed of mostly low-achieving students. Examining cut off scores of the schools in the city center according to the TEOG exam results (TEOG Lise Taban Puanları 2014 2015 MEB, 2015) three schools composed of high-achieving (approximate 440 TEOG base scores), moderate-achieving (approximate 360 TEOG base scores) and low-achieving (approximate 300 TEOG base scores) students were chosen. By this way, the students with various achievement levels were reached.

### *Data Collection*

A cross-sectional survey was used in data collection (Fraenkel & Wallen, 2005). Data were collected through a questionnaire. In it students were first required to respond the questions about their demographic information (gender, grade level), and mathematics and physics grade point average (GPA) scores on a 100 point-scale. These GPA scores were considered as the students' mathematics and physics achievement scores in this study. In addition, the eight-item scale self-efficacy of learning that is one of the dimensions of Motivated Learning Strategies Questionnaire (MSLQ) (Pintrich, Smith, Garcia & McKeachie, 1993) and the scale measuring Attitude towards Physics (ATP) with 30 items (Tekbıyık & Akdeniz, 2010) was included in the questionnaire.

MSLQ was adapted into Turkish by Büyüköztürk, Akgün, Özkahveci and Demirel (2004). Only the dimension self-efficacy of learning in this adapted version was used in this study. The eight-item dimension's Cronbach's alpha reliability coefficient was 0.86 (Büyüköztürk et al., 2004). This scale was a two-sided seven-point scale and the participants were required to indicate how much the items reflect their ideas (Pintrich et al., 1993). The scale measuring students' self-efficacy of learning physics in this study was also modified from self-efficacy of learning dimension of MSLQ.

ATP scale with 30 items, ranging from 1 (strongly disagree) to 5 (strongly agree), had four dimensions that are importance (10 items), comprehension (7 items), requirement (7 items), and interest (6 items) (Tekbıyık & Akdeniz, 2010). This scale's dimensions' (importance, comprehension, requirement, and interest) Cronbach's alpha reliability coefficients were 0.838, 0.795, 0.749, and 0.717, respectively and ATP scale's overall alpha was 0.873 (Tekbıyık & Akdeniz, 2010). Consequently, a unique questionnaire that explores students' demographic background, mathematics and physics achievements, self-efficacy of learning physics, and attitude towards physics were distributed to the students.

## Data Analysis

Data was analyzed using hierarchical regression analysis to elicit the significant predictors of physics achievement. In the hierarchical regression analysis, the independent variables are entered into the regression model by the researcher according to an order. This order of entry of the variables into the hierarchical model could be determined according to the logical or theoretical considerations (Tabachnick & Fidell, 2007). In this study, psychological constructs attitude towards physics and self-efficacy of learning physics were first considered as more powerful predictors of physics achievement because these variables measure something about physics. Moreover, some theorists' (e.g., Bandura, 1993; Fishbein & Ajzen, 1975) ideas about the strong relationship between behavior and psychological constructs influenced the determination of the order of entry of the variables in this study. For example, Fishbein and Ajzen (1975) tried to explain individuals' behavioral intentions and behaviors considering attitudes, and Bandura (1993) indicated the strong relationships between individuals' self-efficacy and performances. In this regard, first of all, students' attitude towards physics and self-efficacy of learning physics were entered into the regression equation to predict their physics achievement. Then the mathematics achievement that was considered as having lesser priority to predict the physics achievement was forced into the equation. However, before starting to perform the regression analysis, whether the data of this study meet the assumptions of regression analysis was examined. At the beginning, three participants' data detected as outliers were removed from the data; and therefore, the analysis was done with the remaining 298 participants' data. At the same time validity and reliability of the scales were tested. Reliability of each scale was tested by calculating Cronbach's alpha reliability coefficient. To test the construct validity of the scales confirmatory factor analysis (CFA) was carried out on AMOS program. Means and standard deviations of each variable were also calculated. Finally, the hierarchical regression analysis was performed

# Results

### *Testing the assumptions of regression analysis*

Before executing regression analysis, whether the data of this study confirm the assumptions of regression analysis was tested. According to Tabachnick and Fidell (2007), some points should be taken into consideration before performing regression analysis, for example, ratio of cases to independent variables, outliers, multicollinearity, singularity, normality, linearity, homoscedasticity, and independence of residuals. Firstly, ratio of cases to independent variables was tested in this study. Having 20 times more cases than independent variables is necessary condition for sample size (Tabachnick & Fidell, 2007). There were six independent variables and 298 cases in this study. Therefore, sample size was appropriate to perform regression analysis.

Then outliers were checked by using z-scores and Mahalanobis distances as suggested by Tabachnick and Fidell (2007). Examining z-scores was also an effective way for initial screening of the data to check normality (Osborne & Overbay, 2004). The three participants' z-score values that were not between -3 and +3 were removed from the data in this study. Remaining data (N = 298) showed that the Mahalanobis distances ranged between .459 and 20.370. The critical value at significance level of .001 for degrees of freedom 6 was 22.458 (Tabachnick & Fidell, 2007). Because there were no cases exceeding the value of 22.458 and the all z-scores were between -3 and +3 in each dimension, it could be claimed that there were no outliers in the data in this study. According to Tabachnick and Fidell (2007), there should not also be multicollinearity in the data to perform regression analysis. To test the multicollinearity condition index (CI), variance inflation factor (VIF) and tolerance values as well as correlations among independent variables were checked. Table 1 presents CI, VIF and tolerance values of the independent variables.

**Table 1.** CI, VIF and tolerance values of the independent variables

| Measures | CI | VIF | Tolerance |
|---|---|---|---|
| Importance | 10.367 | 1.138 | .879 |
| Comprehension | 11.831 | 1.084 | .923 |
| Requirement | 13.373 | 1.176 | .850 |
| Interest | 15.930 | 1.065 | .939 |
| Self-efficacy of learning physics | 19.287 | 1.139 | .878 |
| Mathematics achievement | 27.764 | 1.045 | .957 |

Note: Dependent variable is physics achievement

Required CI, VIF and tolerance values are as follows; CI values should be lower than 30, VIF values lower than 10, and tolerance values higher than .20 (Tabachnick & Fidell, 2007). The values presented in Table 1 satisfied these requirements. In addition, high correlations (.90 and higher) among the independent variables can cause multicollinearity in the data (Tabachnick & Fidell, 2007). Therefore, correlations among observed variables in this study were also examined (see Table 2).

**Table 2.** Correlations among observed variables

| Measures | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Importance | - | | | | | | |
| Comprehension | .024 | - | | | | | |
| Requirement | .310** | .113 | - | | | | |
| Interest | .144* | .168** | .132* | - | | | |
| Self-efficacy of learning physics | .180** | .232** | .234** | .144* | - | | |
| Mathematics achievement | .111 | .048 | .172** | .081 | .132* | - | |
| Physics achievement | .044 | .219** | .232** | .080 | .262** | .483** | - |

** Correlation is significant at the 0.01 level.

* Correlation is significant at the 0.05 level.

As shown in Table 2, maximum correlation value among independent variables (between 1 and 3) was .310. This value did not imply much higher correlation. Therefore, this result can suggest that there is no multicollinearity in the data. In addition, correlation was maximum between mathematics achievement and physics achievement, and minimum between mathematics achievement and 'comprehension'. Another assumption singularity requires that there should not be a variable that is a combination of two or more of the other variables (Tabachnick & Fidell, 2007). In this study, none of the variable was a combination of other variables. Therefore, singularity assumption was also met in this study.

Finally, normality, linearity, homoscedasticity, and independence of residuals assumptions were checked. These assumptions should be confirmed by examining "the residuals scatterplot" and "the Normal Probability Plot of the regression standardized residuals" (Pallant, 2005, p. 150). When the points in the Normal Probability Plot are distributed along a reasonably straight diagonal line, this suggests a normal distribution (Pallant, 2005). All the cases lied in a straight line in this study. Furthermore, according to Tabachnick and Fidell (2007), the residuals scatterplot that resembles a shape of rectangle suggests to meet the assumption of linearity. In this study the residuals' distributions resembled a rectangle more so this assumption was also met. Homoscedasticity can also be checked by examining the residuals scatterplot. If the residuals are randomly scattered around zero point, and they exhibit a relatively even distribution, the data is not heteroscedastic (Osborne & Waters, 2002). Residuals were also randomly scattered around zero point, and showed even distribution in this study. As a conclusion, all the assumptions were met to run the regression analysis.

### *Validity and reliability of the scales*

CFA (N = 298) was performed to test the construct validity of the scales. CMIN/df, and RMSEA values as well as some fit indices CFI, GFI, and TLI were examined. CMIN/df, RMSEA, CFI, GFI, and TLI values of self-efficacy of learning physics scale were found to be 2.414, .069, .977, .956, and .968, respectively. Furthermore, factor loadings (FL), measurement errors (ME), and significance of item loadings (p) of self-efficacy of learning physics scale were examined (see Table 3).

**Table 3.** Factor loadings (FL), measurement errors (ME), and significance of item loadings (p) of self-efficacy of learning physics scale

| | Item | FL | ME | *p* |
|---|---|---|---|---|
| Self-efficacy | 1 | .647 | - | - |
| | 2 | .738 | .108 | < .001 |
| | 3 | .727 | .095 | < .001 |
| | 4 | .680 | .105 | < .001 |
| | 5 | .702 | .100 | < .001 |
| | 6 | .813 | .098 | < .001 |
| | 7 | .849 | .097 | < .001 |
| | 8 | .756 | .099 | < .001 |

As shown in Table 3, minimum factor load value was .647. Measurement errors were below .200 and significance of item loadings was below .001. CFA was also executed to test CMIN/df, RMSEA, CFI, GFI and TLI values of ATP survey. These values were found to be 1.412, .037, .956, .891, and .951, respectively. In Table 4, factor loadings (FL), measurement errors (ME), and significance of item loadings (p) of ATP scale are also presented.

**Table 4.** Factor loadings (FL), measurement errors (ME), and significance of item loadings (p) of ATP scale

| | Item | FL | ME | *p* |
|---|---|---|---|---|
| Importance | 29 | .728 | - | - |
| | 11 | .775 | .076 | < .001 |
| | 9 | .764 | .079 | < .001 |
| | 26 | .770 | .078 | < .001 |
| | 23 | .737 | .079 | < .001 |
| | 28 | .697 | .078 | < .001 |
| | 10 | .743 | .071 | < .001 |
| | 13 | .676 | .080 | < .001 |
| | 27 | .749 | .077 | < .001 |
| | 24 | .780 | .079 | < .001 |
| Comprehension | 14 | .529 | - | - |
| | 19 | .665 | .149 | < .001 |
| | 5 | .724 | .149 | < .001 |
| | 2 | .402 | .147 | < .001 |
| | 20 | .433 | .164 | < .001 |
| | 6 | .650 | .158 | < .001 |
| | 3 | .565 | .180 | < .001 |
| Requirement | 12 | .708 | - | - |
| | 1 | .682 | .084 | < .001 |
| | 17 | .612 | .096 | < .001 |
| | 25 | .620 | .088 | < .001 |
| | 30 | .677 | .088 | < .001 |
| | 15 | .777 | .089 | < .001 |
| | 18 | .797 | .082 | < .001 |
| Interest | 7 | .729 | - | - |
| | 16 | .806 | .097 | < .001 |
| | 21 | .761 | .085 | < .001 |

| | | | | |
|---|---|---|---|---|
| | 8 | .594 | .095 | < .001 |
| | 4 | .503 | .076 | < .001 |
| | 22 | .568 | .090 | < .001 |

As seen in Table 4, minimum factor load was .402 and maximum measurement error was .180. All significance of item loadings was also below .001. Byrne (2010) suggests that the values of fit indices CFA, GFI, and TLI should be above .90, RMSEA value closer to zero, and CMIN/df smaller than 3. When the two scales' (self-efficacy of learning physics scale, and ATP scale) CFA results were considered, it can be claimed that these two scales have a reasonable fit. Thus the two scales were validated.

Cronbach's alpha reliability coefficients were also examined to check the reliability of the scales. The alpha coefficients of self-efficacy of learning physics scale were observed to be .905. In addition, the alpha coefficients of the ATP scale's dimensions 'importance', 'comprehension', 'requirement', and 'interest' were found to be .924, .760, .870, and .835, respectively. ATP scale's overall alpha was also observed to be 0.855. According to Pallant (2005), the values above .700 for the alpha coefficients were satisfactory to claim that the scale is reliable. Therefore, the alpha coefficients found in this study were in acceptable level.

### *Descriptive statistics*

Descriptive statistics including means (M) and standard deviations (SD) of each variable were calculated. Table 5 presents the descriptive results.

**Table 5.** Results of descriptive statistics

| Measures | N | M | SD |
|---|---|---|---|
| Importance | 298 | 4.131 | .671 |
| Comprehension | 298 | 3.139 | .700 |
| Requirement | 298 | 4.011 | .681 |
| Interest | 298 | 3.922 | .713 |
| Self-efficacy of learning physics | 298 | 4.794 | 1.418 |
| Mathematics achievement | 298 | 67.242 | 16.307 |
| Physics achievement | 298 | 68.309 | 13.996 |

As indicated in Table 5, the means of mathematics achievement and physics achievement were very close to each other. In addition, the means of the dimensions of attitude towards physics were almost equal to 4 except the dimension 'comprehension'. This result can suggest that the participants have positive attitude towards physics. The participants' self-efficacy of learning physics mean was also close to 5.

### *Hierarchical regression analysis*

Hierarchical regression analysis was performed to test whether the variables 'importance', 'comprehension', 'requirement', 'interest', 'self-efficacy of learning physics' and 'mathematics achievement' predict physics achievement. Table 6 presents the regression analysis results.

**Table 6.** Results of hierarchical regression analysis

| Independent variables | B | SE | β | t | R2 | ΔR2 |
|---|---|---|---|---|---|---|
| Model 1 | | | | | .125 | .032 |
| Importance | -1.105 | 1.217 | -.053 | -.908 | | |
| Comprehension | 3.076 | 1.140 | .154 | 2.699* | | |
| Requirement | 3.794 | 1.210 | .185 | 3.135* | | |
| Interest | .197 | 1.107 | .010 | .178 | | |
| Self-efficacy of learning physics | 1.888 | .575 | .191 | 3.286* | | |
| Model 2 | | | | | .313 | .188 |
| Importance | -1.558 | 1.081 | -.075 | -1.441 | | |
| Comprehension | 3.029 | 1.012 | .151 | 2.994* | | |
| Requirement | 2.612 | 1.083 | .127 | 2.412* | | |
| Interest | -.185 | .984 | -.009 | -.189 | | |
| Self-efficacy of learning physics | 1.516 | .512 | .154 | 2.963* | | |
| Mathematics achievement | .380 | .043 | .443 | 8.913** | | |

$^{**}p < .001$, $^{*}p < .05$

As shown in Table 6, in model 1 the dimensions in attitude towards physics and self-efficacy of learning physics contributed significantly to the regression model, F (5, 292) = 8.358, $p < .001$. These variables accounted for 12.5% of the variation in physics achievement. In model 2, mathematics achievement was introduced to the equation, and it explained an additional 18.8% variation in physics achievement. This change in R2 was significant, F (1, 291) = 79.443, $p < .001$. In addition, in this model the dimensions 'comprehension' (t = 2.994) and 'requirement' (t = 2.412) in attitude towards physics, 'self-efficacy of learning physics' (t = 2.963), and 'mathematics achievement' (t = 8.913) were significant correlates of physics achievement. There was also a significant relationship between the independent variables taken together and physics achievement in model 2. Together the independent variables significantly explained the 31.3% of the variation in physics achievement, F (6, 291) = 22.077, $p < .001$. Accordingly, the dimensions 'comprehension' ($\beta = .151$), 'requirement' ($\beta = .127$) in attitude towards physics, 'self-efficacy of learning physics' ($\beta = .154$), and 'mathematics achievement' ($\beta = .443$) positively and significantly contributed to the physics achievement in this model. Considering also the beta coefficients mathematics achievement was the strongest positive predictor of physics achievement, when the other variables were controlled.

## Discussion and Implications

In this study the participants' attitude towards physics, self-efficacy of learning physics, and mathematics achievement significantly predicted their physics achievement. First of all, whether the students' attitude towards physics and self-efficacy of learning physics explained their physics achievement was explored. Considering attitudes toward physics the dimensions 'comprehension' and 'requirement' could positively and significantly explain the students' physics achievement but 'importance' and 'interest' could not explain it. The dimensions 'importance' and 'interest' were also tested by Gungor et al. (2007) and they could not find any relations between them and physics achievement. Willson et al. (2000) also could not find any relations between students' physics achievement and their attitude towards physics. In addition, Çapri (2013) found that students' attitude towards physics little predicted their physics achievement. Similarly, in this study, students' physics achievement was not strongly explained by their attitudes. However, Chang and Cheng (2008) also found that students' physics achievement was positively and significantly correlated with their interest in science. The instruments used in the studies to measure the attitudes and achievements and the education systems of the countries could cause these contradictory results. Although in some of the studies (e.g., Çapri, 2013) students' physics achievement was not predicted or little predicted by their attitudes toward physics, some theorists (e.g., Eccles et al., 1983; Fishbein & Ajzen, 1975) claimed that there should be close relationship between attitude and behavior. When the students' physics achievement is considered as a result of their some behaviors such as studying physics, significant and positive strong relationships between students' attitude towards physics and physics achievement have also been expected in this study. Mismatches between what is done in the schools and what is expected in the curricula can cause the insignificant or weak relationships between attitudes and achievements. For example, in Turkey, teachers are required to teach physics considering physics and daily-life relationships and making students active in learning. It is thought that these can also develop students' attitudes, achievements and study habits (MoNE, 2013a). Implementation problems of the curriculum or not implementing it in desired manner could cause the weak predictions in this study. Encouraging students to involve in more hands-on or laboratory activities as well as motivating them to study physics more can increase their both attitude towards physics and physics achievement. In this regard, there may be stronger relationship between students' attitude towards physics and their physics achievement.

The students' self-efficacy of learning physics was also positive and significant predictor of their physics achievement in this study. Students' attitude towards physics and self-efficacy of learning physics together explained the 12.5% variance of their physic achievement. This finding was consistent with the findings of Çapri (2013), and Yerdelen-Damar and Peşman (2013). They also found that students' self-efficacy of learning physics was positive and significant predictor of their physics achievement. Contrary to these findings, Gungor et al. (2007) found insignificant relationship between students' self-efficacy in physics and their physics achievement. The positive and significant relationship between self-efficacy and achievement was also theoretically an expected result. For example, the close relationship between self-efficacy and achieving some goals were widely discussed by Bandura (1997). The positive and significant relationship between students' self-efficacy of learning physics and physic achievement in this study may imply that self-efficacious students can have higher physics achievement. Therefore, improving students' self-efficacy of learning physics can also improve their physics achievement.

The positive stronger predictor of students' physics achievement was their mathematics achievement in this study. In the final model of this study, this contributed to additional 18.8% variation in physics achievement. In fact, the strong positive correlations between students' success in physics and mathematics were indicated (Marsh et al., 2015; Meltzer, 2002; Veloo et al., 2015). However, how students' mathematics achievement predicts their physics achievement was not deeply discussed in these studies. This finding indeed reveals that students' success in physics is mostly predicted by their achievement in mathematics rather than their attitudes and self-efficacy. Therefore, more importance should be given to students' mathematics achievement within the variables if teachers or researchers want to increase students' physics achievement.

These findings may also give researchers some clues about the current physics education in the classrooms. This study showed that the psychological constructs the attitudes and self-efficacy were not as effective as the mathematics achievement in explaining the physics achievement. For example, although serious reforms were put into practice in Turkey to develop students' attitude towards science/physics considering the attitudes' positive influence on students' behavior, some attitudes cannot predict physics achievement in this study. One of the reasons of such a result can be related to implementation of current science/physics curricula. Teachers could not implement the curricula according to the necessities of these curricula as discussed before. For example, they could not make students active in learning using some hands-on or laboratory activities. Instead, they could frequently solve physics problems including too much mathematics and teach physics based on more memorization of formulas and rules. Therefore, they may have had to test students' physics achievement with the physics questions aiming to measure only their problem solving skills. These skills can be composed of putting some values into the memorized formulas, solving some mathematical equations and making some calculations. These could all cause positive stronger relationships between mathematics achievement and physics achievement. Espousing the learning methods or strategies that will provide students more opportunities to develop their attitude towards physics, self-efficacy of learning physics, and mathematics achievement can result in higher physics achievement. Therefore, teachers should be more careful in designing students' learning environments and implementing their lessons. They should choose the learning methods or strategies that will provide students to have better performances in mathematics and physics, higher attitude towards physics and self-efficacy of learning physics. More interdisciplinary learning for mathematics and physics should also be adopted in the curricula.

# Conclusions

This study revealed that only 31.3% of variance in physics achievement was explained. Other demographic variables (e.g., gender, race, socio-economic status), and psychological variables (e.g., epistemologies, motivations) can also explain some of the remaining variance. Therefore, in the future studies these variables can be included to be able to more predict students' physics achievement.

The stronger variable that explains the students' physics achievement was their mathematics achievement. Its influence on explaining physics achievement should not be ignored. Increase in the students' mathematics achievement may strongly result in increase in their physics achievement.

# References

Ajzen, I. (1985). *From intentions to actions: A theory of planned behavior*. In J. Kuhl & J. Beckman (Eds.). Action-control: From cognition to behavior. Heidelberg: Springer.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Physiologist, 28*(2), 117-148.

Bandura, A. (1997). *Self-Efficacy: The Exercise of Control*. NY: W. H. Freeman and Company

Bem, D. J. (1972). *Self-Perception theory*. In L. Berkowitz (Ed.), Advances in Experimental Social Psychology (Vol. 6, pp.1-62). New York: Academic Press.

Büyüköztürk, Ş., Akgün, Ö. E., Özkahveci, Ö., & Demirel, F. (2004). The validity and reliability study of the Turkish version of the motivated strategies for learning questionnaire. *Educational Sciences: Theory & Practice, 4*(2), 231-239.

Byrne, B. M. (2010). *Structural equation modeling with AMOS. Basic concepts, applications and programming*. Taylor & Francis Group: New York.

Çapri, B. (2013). Investigating university students' attitude towards physics lesson, their self-efficacy beliefs and burnout levels for the prediction of their academic success in physics lessons. *Educational Research and Reviews, 8*(10), 646-652.

Chang, C. -Y., & Cheng, W. -Y. (2008). Science achievement and students' self-confidence and interest in science: A Taiwanese representative sample study. *International Journal of Science Education, 30*(9), 1183-1200.

Eccles J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). *Expectancies, values, and academic behaviors*. In J. T. Spence (Ed.), Achievement and achievement motivation (pp. 75-146). San Francisco, CA: W. H. Freeman.

Eryılmaz, A., & Tatlı, A. (1999). A causal model of students' achievement in an introductory mechanics course. *Hacettepe University Journal of Education, 15*, 36-42.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behaviour: An introduction to theory and research.*Reading, MA: Addison-Wesley.

Fraenkel, J. R., & Wallen, N. E. (2005). *How to design and evaluate research in education* (3rd ed.). New York: McGraw-Hill.

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

Jiar, Y. K., & Long, C. Y. (2014). Mathematical thinking and physics achievement of secondary school students. *Sains Humanika, 2*(4), 231-237.

Manstead, A. S. R. , & Van Eekelen, S. A. M. (1998). Distinguishing between perceived behavioral control and self-efficacy in the domain of academic achievement intentions and behaviors. *Journal of Applied Social Psychology, 28*(15), 1375-1392.

Marsh, H. W., Lüdtke, O., Nagengast, B., Trautwein, U., Abduljabbar, A. S., Abdelfattah, F., Jansen, M. (2015). Dimensional Comparison Theory: Paradoxical relations between self-beliefs and achievements in multiple domains.*Learning and Instruction, 35*, 16-32.

Meltzer, D. E. (2002). The relationship between mathematics preparation and conceptual learning gains in physics: A possible ''hidden variable'' in diagnostic pretest scores. *American Journal of Physics, 70*(12), 1259-1268.

Ministry of National Education [MoNE] (2013a). High Schools Physics Curriculum.

Ministry of National Education [MoNE] (2013b). Primary and Elementary Schools Science Curriculum.

Mullis, I. V. S., & Martin, M. O. (Eds.) (2013). *TIMSS 2015 assessment frameworks. Chestnut Hill*, MA: TIMSS & PIRLS International Study Center, Boston College.

National Research Council (1996). *National science education standards.* Washington, DC: National Academy Press.

Osborne, J., & Waters, E. (2002). Four assumptions of multiple regression that researchers should always test. *Practical Assessment, Research & Evaluation*, 8(2).

Osborne, J. W., & Overbay, A. (2004). The power of outliers (and why researchers should always check for them). *Practical Assessment, Research & Evaluation*, 9(6).

Pallant, J. (2005). *SPSS survival manual: A step by step guide to data analysis using SPSS for windows (Version 12).* (2nd ed.) Maidenhead: Open University Press.

Pajares, F., & Schunk, D. H. (2001). *Self-beliefs and school success: Self-efficacy, self-concept, and school achievement.* In R. Riding & S. Rayner (Eds.), Self-perception(pp. 239-266). London: Ablex Publishing.

Papanastasiou, E. C., & Zembylas, M. (2002). The effect of attitudes on science achievement: A study conducted among high school pupils in Cyprus, *International Review of Education, 48*(6), 469-484.

Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement, 53*(3), 801-813.

Schunk, D. H. (1984). Self-efficacy perspective on achievement behavior. *Educational Psychologist, 19*(1), 48-58.

Simpson, R. D., Koballa, T. R., Oliver, J. S., & Crawley, F. (1994). *Research on the effective dimension of science learning.* In D. Gable (ed.). Handbook of research on science teaching and learning (pp. 211-234). New York: Macmillan.

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Boston, Massachusetts: Allyn and Bacon.

Tekbıyık, A., & Akdeniz, A. R. (2010). A contemporary physics attitude scale for secondary school students: development, validity and reliability. *Journal of Turkish Science Education, 7*(4), 134-144.

TEOG Lise Taban Puanları 2014 2015 MEB. (June 8, 2015). Retrieved from http://www.eokul-meb.com/teog-lise-taban-puanlari-2014-yeni-66102/

Veloo, A., Nor, R., & Khalid, R. (2015). Attitude towards physics and additional mathematics achievement towards physics achievement. *International Education Studies, 8*(3), 35-43.

Willson, V. L., Ackerman, C., & Malave, C. (2000). Cross-time attitudes, concept formation, and achievement in college freshman physics. *Journal of Research in Science Teaching, 37*(10), 1112-1120

Yerdelen-Damar, S., & Peşman, H. (2013). Relations of gender and socioeconomic status to physics through metacognition and self-efficacy. *The Journal of Educational Research*, *106*(4), 280-289.

Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology, 25*(1), 82-91.