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EFFECTS OF GENDER, COGNITIVE DEVELOPMENT AND SOCIOECONOMIC STATUS ON PHYSICS ACHIEVEMENT

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ABSTRACT: The study described in this paper attempted to investigate the combined and individual effects of certain variables (gender, cognitive development and socioeconomic status (SES)) on physics achievement. We used a physics achievement test, logical thinking ability test and a socioeconomic status questionnaire to assess 35 high school second grade students' physics achievement, cognitive level and socioeconomic level. We used Multiple Regression and Correlation Analysis (MRC) for analyzing data obtained from those tests. The analysis of data revealed that male students generally got higher scores in physics than female students. The cognitive level of students did not affect their score on achievement test. Socioeconomic level of the students showed significant effect on their physics achievement.

KEY WORDS: *Physics Achievement, Cognitive Development, Socioeconomic Status, and Gender.*

ÖZET: Bu makalede bahsedilen çalışmada, bazı değişkenlerin (cinsiyet, bilişsel gelişim ve sosyoekonomik durum) fizik başarısına olan etkisi bütün ve ayrı ayrı ele alınmıştır. 35 lise 2 öğrencisine fizik başarısını, bilişsel gelişim seviyesini ve sosyoekonomik düzeylerini ölçmek için fizik başarı testi, mantıksal düşünme yeteneği testi ve sosyoekonomik durum ölçeği verildi. Bu testlerden elde edilen sonuçlar çok değişkenli regrasyon ve ilişki analizi (MRC) metodları kullanılarak analiz edildi. Verilerden elde edilen sonuçlar, erkek öğrencilerin fizikte genellikle kız öğrencilerden daha yüksek not aldıklarını gösterdi. Öğrencilerin bilişsel seviyelerinin fizik başarısına etkisi olmadığı ortaya çıkarken, sosyoekenomik düzeyleri yüksek olan öğrencilerin, sosyoekonomik düzeyleri daha düşük olanlara oranla fizikte daha başarılı oldukları ortaya çıktı.

ANAHTAR SÖZCÜKLER: *Fizik Başarısı, Bilişsel Gelişim, Sosyoekonomik Düzey ve Cinsiyet.*

1. INTRODUCTION

Because of the high technological changes during the last few decades, nations turned their interests to science education. There were many studies carried out about science education, concerning either its problems or possible improvements about it. Research findings of previous studies showed that there are several factors affecting students' science and physics achievement [1, 2, 3 and 4]. It is inevitable that those factors are also effective on students' physics achievement. Some of the factors mentioned in those studies are students' gender, age, cognitive development, previous knowledge, mathematics achievement, attitude, socioeconomic status and achievement expectations. In this study, we will look into the effects of three of those factors. These three factors are students' gender, cognitive development and socioeconomic status. Hence the main purpose of this study is to investigate the effects of students' gender, cognitive development and socioeconomic status on their physics achievement.

Throughout this study, we used the phrase cognitive development as described by Piaget for the stages, organized patterns of behavior or thought that children formulate as they interact with their environment. Piaget described a sequence of four stages of cognitive development. Progress through the stages can occur at different rates, but it always orderly, taking place in an invariant sequence. Each stage is characterized by the development of cognitive structures, or schemes. A scheme is a coordinated pattern of thought or action that organizes an individual's interaction with the environment. The stages described are sensorimotor, preoperational, concrete operational and formal operational stages [5]. Socioeconomic status as used through this study refers to the level of students' socioeconomic background as assessed by their parents' occupation, educational level, family income, family size and some other variables.

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2. LITERATURE REVIEW

Literature review of this subject indicates that the three factors; gender, cognitive development and SES have significant effects on students' physics achievement. Research findings of most studies carried out in the last few decades indicate significant gender differences in physics achievement between males and females in favor of males [3, 4, 6, 7, 8, 9, and 10]. Eryılmaz [3], in a study of 435 university students, points out that male students do better in physics than females. The results of the study in which the data obtained from Second International Science Study (SISS) were used to indicate parallel results: Male students get higher scores than female students in physics [6]. The data used in the study were obtained from a sample of 2719 12^{th} grade students studying physics for the first time and 485 advanced physics students. Ehindero [7], also points out the same result in another study. 35 male and 35 female high school students participated in the study. Result of the study is the same as the results of previously mentioned studies. Young and Fraser [4], by using the results of Australian SISS, point out the same result. There is a gender difference in science achievement in favor of males. In the study, 4917 14-year-old Australian students' data were analyzed. Young and Fraser [8], indicate the same result that there is statistically significant sex difference favoring boys in physics achievement. They used the data obtained in the Australian SISS. In that study, 13057 (6574 males, 6432 females and 51 unknown) students participated. Young [9], by analyzing the data obtained from 51,014 14-year-old students from 12 countries who participated in SISS, indicates the difference between males and females. In that study, it is cited that males consistently and significantly outperform females in science achievement. Young [10], points out the same result: boys are outperforming girls in both science and mathematics achievement. In this study, data were obtained from 3397 students.

In research findings of the studies made in the last two decades indicate that students' cognitive development affects their physics achievement [2, 11 and 12]. In a study of 20 students, results point out a correlation between the formal operational reasoning and performance in physics [2]. A multiple-regression analysis indicates that the test scores of formal operational reasoning were strong predictors of course performance. Renner [11], indicates that students' cognitive level has significant effect on their achievement. He says, "Of special significance is the fact that no students in the concrete operational category achieved any success with formal questions" (p. 220). In a study of 195 randomly chosen university students, results indicate the effectiveness of cognitive development on physics achievement [12]. In another study, using a sample of 65 students, a significant positive correlation between Piagetion level and physics achievement is found (Sills, 1977; cf., [12]).

The results of the studies carried out in the last decade also showed the significant effect of SES on students' science achievement [4, 9, and 11]. The result of a study [4] indicates significant positive and large effect of students' socioeconomic status on their science achievement. In that study, data obtained from the 4917 14-year-old Australian students who participated in SISS were analyzed. The students' socioeconomic status was assessed by considering their parents' occupations, education and family size. Young [9] points out the same result in another study: Students from higher socioeconomic background tend to outperform those students from poorer homes. In that study, what is meant by the SES is assessed by parents' occupations, mother's educational level, number of books in home, and family size. The data were obtained from 51014 14-year-old students from 12 countries who participated in SISS in 1984. In another study [10], results indicate the same conclusion: achievement is higher for those students coming from higher socioeconomic background. In this study, 3397 8-year, 9-year and 10-year students' data were used.

Regarding the results of the past researches, this study is aimed at estimating unique and com-

bined effects of students' gender, cognitive development and socioeconomic status on their achievement. Although the past researches focused more on science achievement, especially while studying the effect of socioeconomic status, we expect to find similar results for physics achievement.

3. METHODOLOGY

3.1 Subjects

The sample of this study consists of 52 high school second grade students taking second year physics course. Although there were 52 students participating in the study, the data of 35 students were used throughout the analyses because of missing data in the dependent variable. The sampling used in this study was convenience.

3.2 Measuring Tools

The data covering physics achievement, cognitive development, and socioeconomic status of 52 10^{th} grade students were gathered by using three tests.

First test was physics achievement test, including items from physics for measuring students' achievement. This test consisted of 15 multiple-choice questions. The questions covered electricity, which was taught in that semester in the second year of the high school. All the questions were selected among the questions previously asked in the University Entrance Examinations. Therefore, reliability and the validity of the test would not be a problem since those questions were constructed and tested by experts. The maximum possible score a student can get in this test is 15 and minimum is 0.

Second test, logical thinking ability test, included items aimed at measuring students' logical thinking ability, which we will refer throughout the study as cognitive development. Logical thinking ability test consisted of 8 multiple choice items each having two parts, and 2 supply type questions. In the first part of each item, students were asked to give an answer presented in each question. In the second part of the items, they are asked to give reason for selecting that answer in the first part. This test was originally developed and validated in a previous study (Tobin and Capie, 1981; cf., [13]), and translated and adapted into Turkish by Geban, Özkan and Aşkar [14]. The reliability of the test was found as 0.81, which is high. In this test, maximum possible score that a student can get is 10 and minimum is 0.

Last test, Socioeconomic status questionnaire, included questions aimed at assessing students' socioeconomic level and assessing their gender. Socioeconomic status questionnaire consisted of 13 questions. Questions were about parents' occupations, educational levels, family income, family size, and so on. This test was modified from one of the previous studies [15].

3.3 Procedure

The subjects participated in this study were 52 10^{th} grade students at Middle East Technical University Foundation High School. The data were collected from physics achievement test, logical thinking ability test and socioeconomic status questionnaire. The data obtained from those tests were analyzed by MRC. Throughout the analyses, first the statistical significance of the combined effect of students' gender, cognitive development and socioeconomic status on their physics achievement was tested. In the second step of the analyses, we tested the statistical significance of the main effects of gender, cognitive development and socioeconomic status. Throughout the analyses, gender was treated as categorical variable and coded as "0" for female students, and "1" for male students. Cognitive development was treated as continuous variable. High scores from logical thinking ability test showed high cognitive level, whereas low scores showed low level of cognitive development. While giving scores to students for those eight multiple choice items from logical thinking ability test, the students were expected to give right answers to both parts of each item. If a

student gave right answer to the question and why he/she answered that question to that question, then it is worth giving one point to the student for that question. Otherwise, no partial point would be given to the students. The socioeconomic status was treated as continuous variable also. The high scores from the questionnaire showed high socioeconomic level whereas low scores showed low socioeconomic level.

4. RESULTS

The descriptive statistics (mean, standard deviation, range, minimum, and maximum) for dependent and independent variables (Physics achievement, cognitive development and SES) are given in Table 1.

Table 1. Descriptive Statistics for Dependent and Independent Variables

	Achievement	Cog. Dev.	SES
Mean	10.40	7.37	27.34
Standard Deviation	2.48	1.66	3.69
Range	11	6	16
Minimum	4	4	20
Maximum	15	10	36

As seen from Table 1, achievement scores have a mean of 10.40 with a standard deviation of 2.48. The scores from physics achievement test distributed normally, ranging from 5 to 15. Scores from cognitive development test have a mean of 7.37 with a standard deviation of 1.66. Scores from logical thinking ability test have a left-skewed distribution. Students' scores from socioeconomic status questionnaire ranging from 20 to 36 distributed normally, with a mean of 27.34 and standard deviation of 3.69.

Table 2 shows the results of first step of statistical analysis, which aims to investigate the combined effect of three independent variables on the dependent variable.

Table 2. MRC Results for Combined Effect of Gender, Cognitive Development and Socioeconomic Status

Regression Statistics	
Multiple R	0.634
R Square	0.402
Adjusted R Square	0.345
Standard Error	2.014
Observations	35

	df	SS	MS	F	Significance F
Regression	3	84.66	28.22	6.96	0.001
Residual	31	125.74	4.06		
Total	34	210.40			

As can be seen from Table 2, there is a quite good correlation between physics achievement and three variables; gender, cognitive development and socioeconomic status (0.634). As the table indicates, three variables together explain a significant amount of variance in students' physics achievement scores. This result is statistically significant at 0.05 level of significance ($p<0.05$). With $R^2=0.402$, analysis points out that 40.2 % of R^2 the variance in students' physics achievement scores can be explained by those three factors: Gender, cognitive development and socioeconomic status. This also means that 59.8 percent of the variance in students' physics achievement scores can not be explained by three factors and there are other factors explaining the remaining variance.

Table 3 represents the results indicating the statistical significance of each independent variable; gender, cognitive development and socioeconomic status on physics achievement.

Table 3. Results of Multiple Regression Analysis for Investigating the Effects of Three Variables

	Coefficients	Standard Error	t ratio
Intercept	-0.889	2.876	-0.309
Gender	1.547	0.717	2.156*
Cog. Dev.	0.233	0.209	1.118
SES	0.314	0.096	3.276*

* $p < 0.05$

As can be seen from Table 3, gender has a significant effect on students' physics achievement. This result is statistically significant at 0.05 level of significance ($p<0.05$). There is a significant gender difference in physics achievement, in favor of males. Although cognitive development seems to have effect on students' physics achievement according to Table 3, this result is not significant at 0.05 level of significance ($p>0.05$). Socioeconomic status has significant effect on students' physics achievement. This results is significant at 0.05 level of significance ($p<0.05$). This means that students from high socioeconomic background generally tend to get higher scores from physics than those from low socioeconomic background.

By using Table 3, we can write a multiple regression equation for estimating physics achievement score from three independent variables; gender, cognitive development and socioeconomic status as;

$$Y = 1.547^* X_1 + 0.233^* X_2 + 0.314^* X_3 - 0.889$$

Where Y, X_1, X_2, and X_3 represent the predicted physics achievement score, gender, cognitive development and socioeconomic status scores, respectively.

5. DISCUSSION

This study deals with the investigation of the unique and combined effects of gender, cognitive development and socioeconomic status on physics achievement. The results from multiple regression and correlation analysis indicated that students' gender, cognitive development and socioeconomic level together explain a significant amount of variance in the students' physics achievement scores. Indeed, we do not claim that the combined effect of three variables is not due to the three variables. There might be other confounding variables that have effects on the dependent variable. Since we did not know what they are or even did not treat some of the factors as confounding variables, we do not claim that those combined effect is due to only those three variables. Moreover, students' gender and socioeconomic status have statistically significant effect on their physics achievement. For instance, male students generally get higher scores than female students, and students from high socioeconomic background tend to get higher scores than those from low socioeconomic background. These results are expected from this study because literature review also has the same results. On the other hand, the findings indicated that cognitive development does not have statistically significant effect on students' physics achievement. This is somewhat surprising for us. As in the case of past studies, we expected to find a significant correlation between cognitive development and physics achievement. However, there is no significant effect. This may be caused by the reluctance of the participants of the study to complete the cognitive development test. Because, students were expressing their feeling as they were really bored with those kinds of tests during administration of the test. We think that students were already tested by the similar or same test before.

6. Recommendations and Implications

The present study has brought to light a number of potentially useful and interesting topics for further studies. One is the sample size. For better results, size of the sample must be as large as possible. Second, as mentioned before, the students showed negative attitude toward cognitive development test, therefore, a better test should be developed for assessing cognitive level of the stu-

dents. Third, the results of the statistical analysis showed that approximately 60% of the variance in physics achievement could be explained by other factors. Consequently, future research should include other factors also.

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