Correlation study of physics achievement, learning strategy, attitude and gender in an introductory physics course

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Contents

Abstract

This study investigates the relationship between multiple predictors of physics achievement including reported use of four learning strategy clusters (elaboration, organization, comprehension monitoring and rehearsal), attitudes towards physics (sense of care and sense of interest) and a demographic variable (gender) in order to determine the significant predictors of physics achievement. The subjects involved in this study were 357 first and second year pre-service teachers at Dokuz Eylul University in Turkey. Subjects were asked to fill out a personal information form, the revised Learning Strategies Scale for Physics Learning (R-LSSPL) and

the Scale of Attitudes towards Physics (SAP). Correlation analyses indicate significant relationships between some variables of the study. Multiple regression analyses (stepwise) revealed that learning strategies accounted for 73% of the variation in physics achievement and all the learning strategy clusters (p<0.001) were found to be statistically significant predictors of physics achievement. The implications of these results for physics education are discussed in this paper.

Keywords: Physics achievement, learning strategies, attitude, gender

Introduction

It is claimed that academic success or failure is related to many factors. In general, the various studies that attempt to explain academic failure do so by beginning with three elements that intervene in education: parents (family causal factors); teachers (academic causal factors); and students (personal causal factors) (Diaz, 2003). When literature on physics education is reviewed, it is seen that the most frequently analyzed personal variables relating to achievement are gender, attitude and motivation. The correlation between students' achievement in physics and gender has been a popular research subject in recent years. The findings of several studies show that there is a correlation between students' achievement in physics and their gender, and that male students are more successful than their female peers at learning physics (see Pollock, Finkelstein, & Kost, 2007; Kost, Pollock, & Finkelstein, 2009; Kost-Smith, Pollock, & Finkelstein, 2010). The studies examining the relationship between achievement in physics and gender present findings demonstrating that factors such as student's age (Beaton et al., 1996; Kahle & Meece, 1994), attitude and interest towards physics (see Kahle, Parker, Rennie, & Riley, 1993; Baker & Leary, 1995; Farenga & Joyce, 1997; Jones, Hove, & Rua, 2000) and social and linguistic behaviour (Stadler, Duit, & Benke, 2000) are pretty effective moderator variables regarding this relationship.

Another student variable that is thought to correlate with achievement in physics is learning strategies. Learning strategies (LSs) are defined as "behaviors and thoughts that a learner uses for processing information during learning" (Weinstein & Mayer, 1986). In education literature, there are various different classifications of LSs. Cognitive psychologists divide LSs into two main categories: cognitive and metacognitive. Vaidya (1999) describes these strategies as follows: Cognitive strategies are used in cognitive processes by helping a person to manipulate information such as note taking or asking questions, through various rehearsal,

elaboration and organizational strategies. Vaidya (1999) argues that cognitive strategies tend to be task specific, that is, certain cognitive strategies are helpful only when learning or processing certain tasks. Metacognitive strategies are described as executive in nature (Vaidya, 1999), used for planning, monitoring and evaluating learning and for regulating progress (Najar, 1999).

Research on LSs shows that there is a relationship between the use of learning strategies and achievement in various academic disciplines (see Green & Oxford, 1995; Yumuşak, Sungur, & Çakıroğlu, 2007; Shin, Jeon, & Yang, 2010) and gender (see Sheorey, 1999; Carr, Jessup, & Fuller, 1999).

The relationship between physics and learning strategies has also been explored in a number of studies recently. These studies can be categorized into two groups. The first group of studies focuses on the use of strategy (Wee, Baacquie, & Huan, 1993; Sezgin Selçuk, Çalışkan, & Erol, 2006; Sağlam, 2010); whereas, the second one does so on strategy teaching (e.g., Koch & Eckstein, 1991; Koch, 2001; Rouet, Vidal-Abarca, Erboul, & Millogo, 2001). Research shows that strategy teaching definitely has positive impacts on learning outcomes such as success, reading comprehension and remembering. As far as is known, there is no correlation study examining the relationship between achievement in physics and use of learning strategies.

Some research has presented findings showing the connection between gender and utilization of learning strategies (see Cekolin, 2001; Goh & Foong, 1997; Sheorey, 1999). So far, this researcher has discovered only one study (Wee et al., 1993) analyzing the correlations among achievement in physics, gender and learning strategies. Therefore, more research is needed in this area.

In this study, the relationships among learning strategy use, attitude, gender and physics achievement and how they jointly influence pre-service teachers' physics achievement in the context of Turkish culture were investigated. The following research questions directed the study:

1. Is pre-service teacher physics achievement correlated with reported frequency of learning strategies use, attitude toward physics and gender?

2. Which independent variables predict student achievement in introductory physics classes?

Methodology

This is a descriptive correlation survey design that was performed at an education faculty in Izmir in Turkey during the 2009-2010 academic year. The research instruments were administered at the end of the spring semester to pre-service teachers receiving traditional instruction. In this study, the predictor variables include the reported frequency of learning strategy use (elaboration, comprehension monitoring, rehearsal, organization clusters), attitude towards physics (sense of interest, sense of care) and gender to explain the dependent (or criterion) variable, physics achievement.

Participants

The participants in this study were 357 first and second-year pre-service teachers (female=220, male=137) who were enrolled in the Departments of Physics, Chemistry, Secondary Mathematics, Primary Mathematics, and Biology Education at Dokuz Eylul University (DEU). At DEU education is carried out in Turkish language. The mean age of the subjects was 20 years (with a standard deviation of 1.2).

Instruments

The research instruments used were the Revised Learning Strategies Scale for Physics Learning, the Scale of Attitudes towards Physics, and the Personal Information Form. The details of the instruments are explained below.

The Revised Learning Strategies Scale for Physics Learning (R-LSSPL)

To measure the frequency of the use of LSs in physics, subjects were given the revised "Learning Strategies Scale for Physics Learning." The "Learning Strategies Scale for Physics Learning" was developed by Sezgin Selçuk (2004) to determine the learning strategies used by students when studying physics during classes. The scale was revised by removing some items from the scale by Sezgin Selçuk and Çalışkan (2010). The revised Learning Strategies Scale for Physics Learning (R-LSSPL) is a 39-item scale, where each item is evaluated on a 5-point Likert-type format with five response options. Those are respectively "always," "frequently," "sometimes," "seldom," and "never." The items on the scale have been categorized into four subscales as "elaboration" (18 items, α=0.90),

"organization" (8 items, α=0.77), "rehearsal" (7 items, α=0.77) and "comprehension monitoring" (6 items, α=0.78). Cronbach's Alpha reliability coefficient for the scale is 0.93. The items on the scale are numbered 5, 4, 3, 2, and 1 starting with the "always" option. The minimum score for the questionnaire is 39, and the maximum score is 195.

Examples that illustrate subscale items for the R-LSSPL are:

Elaboration: "I learn subject matter by relating it to daily life;" "I always compare what I have just learnt to my existing knowledge."

Comprehension monitoring: "When I cannot answer a question or solve a problem, I always think of what could be the reason for that;" "I try to notice what knowledge I lack."

Rehearsal: "I always review my lecture notes the same day, either orally or by rewriting them;" "I always go over the example problems that my instructor solved in class, and try to solve those again."

Organization: "I draw charts in order to understand the relationship between concepts;" "To comprehend a case in physics, I either draw its picture or a diagram."

The Scale of Attitudes towards Physics (SAP)

To determine student attitudes towards the physics course, I used SAP which was developed by Sezgin Selçuk (2004). It comprises 40 items. SAP is a 5-point Likert scale (Highly Applicable, Applicable, Neutral, Inapplicable, Highly Inapplicable). Twenty two of the items reflect positive attitudes; while 18 reflect negative attitudes. It is a two-factor scale with a Cronbach Alfa reliability coefficient of 0.97. The factor loading for each item was above 0.40. The percent of total variance explained by two factors was 53.4%. These factors were "sense of interest" and "sense of care" respectively. "Sense of interest" has 25 items, with a reliability coefficient of 0.96. Examples of items include "having an interest in physics" and "enjoying physics." Examples of items that compose the "sense of interest" factor are: "I am interested in everything related to physics" and "I am not interested in physics except for when I am in class." The alpha coefficient for "sense of care" was 0.90, and is made up of 15 items. Examples of items are: "I think physics is

important," and "I think physics is a course that needs to be learnt." The minimum score for the scale is 40, while the maximum score is 200.

The Personal Information Form

This form includes demographic variables such as student gender, age and physics course variables (Physics I and Physics II grades and teaching methods used in the courses).

Data Analysis

The data obtained from the revised Learning Strategies Scale for Physics Learning, "The Scale of Attitudes towards Physics," and the Personal Information Form (gender type and physics achievement) have been analyzed using the SPSS (Version 13.0) statistical analysis program. Frequencies (n), percentages (%), means (M) and standard deviations (SD) were calculated. In this study, in order to see how accurately the independent variables could predict student grades in physics, the researcher used Multiple Linear Regression (MLR) Analysis. For the gender variable, "Female" was coded as 1 and "Male" was coded as 2. For data regarding academic success of students that completed the questionnaires, the researcher used the average of their final passing grades for Physics I and Physics II.

Results

Means and standard deviations for all the measures are presented in Table 1. Further analyses of bivariate relationships between variables were carried out as indicated in Table 2. Table 2 displays the Pearson correlation among variables and the two-tailed probability for each correlation coefficient.

Table 1 *Descriptive Statistics for all Variables*

Variable	M	SD	n
Physics Achievement	49.16	15.28	357
Elaboration	58.20	12.14	357
Comprehension monitoring	19.42	4.63	357

Rehearsal	24.66	4.98	357
Organization	26.97	5.78	357
Sense of interest	67.99	24.62	357
Sense of care	49.69	13.02	357
Gender	1.38	0.487	357

Table 2 *Pearson's Correlation Coefficients of Physics Achievement and the Selected Variables (Learning Strategy, Attitude and Gender)*

Variable	PA	ES	CMS	RS	OS	SI	SC
PA							
ES	0.739**						
CMS	0.690**	0.545**					
RS	0.619**	0.458**	0.618**				
OS	0.646**	0.436**	0.534**	0.563**			
SI	0.025	0.011	-0.028	0.001	0.002		
SC	0.071	0.014	0.004	0.036	0.040	0.855**	
Gender	-0.086	0.079	-0.048	-0.217**	-0.225**	-0.037	-0.019

Note: Significant for **p<0.01

PA=Physics Achievement, ES=Elaboration Strategy,

CM=Comprehension Monitoring Strategy, RS=Rehearsal Strategy,

OS= Organization Strategy, SI= Sense of Interest, SC= Sense of Care

As can be seen from Table 2, elaboration, comprehension monitoring, rehearsal, and organization strategy clusters in the Revised Learning Strategies Scale for Physics Learning (R-LSSPL) correlated with pre-service teacher physics achievement scores. The correlation was significant and positive ranging from 0.62 to 0.74 (p<0.01). In addition, small but significant correlations were found between gender and rehearsal and organization clusters (r = -0.217 and -0.225, respectively). From Table 3, it is observed that the elaboration cluster has the highest correlation with physics grades (r = 0.739; p<0.01).

After the assumptions validation, an initial Multiple Linear Regression (MLR) analysis was performed on the dependent variable Physics Achievement, entering all independent variables (ES, CMS, RS, OS, SI, SC and gender). The results of the

regression analysis for the prediction of student achievement in physics in terms of learning strategy, attitude and gender variables are presented in Table 3.

Table 3 *The Results of the Multiple Regression Analysis Concerning the Prediction of Students' Achievement in Physics*

Variable	B	Std. Error	β	t	p	Zero-order r	Partial r
Constant	-27.587	3.380	-	6.470	0.000	-	-
ES	0.567	0.044	0.451	13.035	0.000	0.739	0.572
CMS	0.777	0.128	0.235	6.065	0.000	0.690	0.309
RS	0.366	0.118	0.119	3.107	0.002	0.619	0.164
OS	0.648	0.095	0.245	6.824	0.000	0.646	0.343
SI	-0.40	0.033	-0.065	1.214	0.226	0.025	-0.065
SC	0.124	0.063	0.105	1.963	0.050	0.071	0.104
Gender	-0.916	0.925	-0.029	0.990	0.323	-0.086	-0.053

By applying Multiple Linear Regression Analysis (MLR), it has been identified how accurately learning strategy, attitude and gender variables can predict student physics grades. As a result of this operation, it was found out that R=0.858, Adjusted R^2=0.731, p = 0.000. Finally, it was also found that 73% of the total variance in student achievement in physics can be explained by these variables. However, gender and attitude are not significant predictor variables of student achievement in physics.

To assess which independent variables made a significant contribution to the prediction of physics grades, Stepwise Regression was used. In Stepwise Regression, the first step is to model the dependent variable and the independent variable with the highest correlation (see Table 2). Through Stepwise Regression, it was possible to determine which variables significantly predicted student physics grades as well as determine how much each variable contributed to the total variance (see Tables 4 and 5).

Table 4 *Stepwise Regression Analysis for Predictors of Student Achievement in Physics*

Model	R	R2	Adjusted R2	Std. Error of Estimate
1	0.739	0.546	0.545	10.308
2	0.822	0.675	0.673	8.735
3	0.850	0.723	0.721	8.079
4	0.856	0.732	0.729	7.958

Table 5 *B and Beta Coefficients, and Significance Levels for Variables*

Model	Predictors	B	Std. Error	β	t	p
1	(Constant) Elaboration	-5.002 0.931	2.675 0.045	 0.739	-1.80 20.683	0.062 0.000
2	(Constant) Elaboration Organization	-20.707 0.711 1.055	2.626 0.042 0.089	 0.565 0.399	-7.887 16.791 11.851	0.000 0.000 0.000
3	(Constant) Elaboration Organization Comp.Monitoring	-23.458 0.574 0.781 0.935	2.454 0.043 0.090 0.120	 0.456 0.295 0.283	-9.559 13.353 8.718 7.794	0.000 0.000 0.000 0.000
4	(Constant) Elaboration Organization Comp.Monitoring Rehearsal	-26.134 0.556 0.676 0.765 0.398	2.540 0.043 0.093 0.128 0.116	 0.442 0.256 0.232 0.130	-10.291 13.036 7.248 5.978 3.438	0.000 0.000 0.000 0.000 0.001

In the first model (see Tables 4 and 5), the elaboration variable was introduced into regression equation. The elaboration variable explained 54.6% of the total variance in physics grades ($R = 0.739$, $R^2 = 0.546$). In other words, the elaboration strategies variable was the most influential predictor of the physics grade. The fact that there is a positive Beta value shows that there is a parallel relationship between the physics grade and elaboration, because as the elaboration score increases, the grade increases.

In the second regression model, the organization variable was added. Consequently, the variance in physics grade rose from 54.6% to 67.5% ($R = 0.822$, $R^2 = 0.675$). This means that the organization variable contributed to the overall variance an additional 12.9%. The Beta value for the organization variable (0.300) shows that there is a positive correlation between organization and physics achievement, because the physics grade increased in the same direction as the rise in organization score.

In the third regression model, the comprehension monitoring variable was included in addition to the elaboration and organization variables. The variance in physics grade increased from 67.5% to 72.3% indicating that the comprehension monitoring variable contributed to the variance a further 4.7%.

Finally, in the fourth model, the variable rehearsal was added to the other three variables. The variance increased from 72.3% to 73.2%. Although this increase was significant, it was small.

The final model used only four predictor variables. The predictor variables of attitude clusters and gender were not significant. The regression model was significant ($F_{[4, 352]} = 240.330$; $p<0.001$) and yielded an adjusted R^2 of 0.729. In summary, Multiple Regression Analyses revealed that learning strategies accounted for 73.2% of the variation in physics course achievement.

Discussion

This study examined predictor variables for pre-service teacher achievement in physics as well as the relationships among them. The findings indicate that:

1. Physics achievement significantly and positively correlated with the elaboration, organization, comprehension monitoring and rehearsal strategy clusters of R-LSSPL. This indicates that pre-service teachers who use these strategy clusters tend to be higher achievers in physics than those who do not. It has also been demonstrated by this study that gender and attitude as predictor variables have no significant effect on pre-service teacher success in physics.

2. Small but significant correlations were found between gender and two clusters of R-LSSP (rehearsal and organization clusters). This indicates that female

students employ rehearsal and organization strategies more often than male students.

The first finding is consistent with the the literature demonstrating that there are significant relationships between the use of learning strategies and academic success. Park (1997) found that good performance by students in language learning strongly related to their use of learning strategies. Thiessen and Blasius (2008) and Dermitzaki, Andreou, and Paraskeva (2008) support Park in terms of performance in mathematics and reading comprehension respectively. Pintrich, Smith, Garcia and McKeachie (1993); however, showed that all learning strategy scales, except for "rehearsal," were positively and significantly correlated with student final achievement. In contrast, Yumuşak et al. (2007) determined that "rehearsal" and "organization" contributed significantly to the prediction of achievement scores in science, particularly in biology. Unlike the findings of this study, Cavallo, Rozman, Blickenstaff and Walker (2003) found that rote learning (or memorization) negatively predicted achievement in science courses.

This study also revealed that gender and attitude towards physics did not have any significant effect on academic success. Findings from several studies indicate that male students are far more successful than their female peers in comprehending physics (see Chambers & Andre, 1997; Beaton et al., 1996; Kahle & Meece, 1994; Wee et al., 1993). When explaining the relationship between gender and success in physics, researchers use attitude as a moderator variable. However, in this study, no significant correlation was found between gender and attitude. The studies cited above were conducted in western countries, so may have been culture specific. Alternatively, the research cited is significantly dated and may reflect past trends rather than indicating emerging realities. A study by Ateş (2008), whose sample was Turkish, found that the relationship between gender and student achievement depends on the questions asked. This study suggests there is no difference between female and male student ability to achieve in physics.

Yet, there were differences between levels of conceptual comprehension between females and males. Ateş (2008) claims that there is a connection between female and male student achievement in physics and the way success in physics is measured. One of the findings of this study indicates that female students use rehearsal strategies (repetition, rote memorization) more frequently than male students. In the same way, Kahle and Lakes (1983) state that female students regard

learning science as memorization of some phenomena, so they think that memorization techniques should be used to learn science. Wee et al. (1993) analyzed the performance of a group of university students in Singapore during exams. They found that female students used learning strategies that were less successful in exams than male students. They came to the conclusion that female students prefer independent learning strategies far less than their male peers. Some researchers (Reap & Cavallo, 1992) were unable to find any effects of gender on approaches employed by students when learning.

Conclusion and Suggestions

In the light of the results of the analysis, it can be deduced that learning strategy use may have positive effects on physics achievement for pre-service teachers. The study provides little support for the hypothesis that girls tend to engage in rote learning in science classes. As seen in this research, reliable and valid questionnaires will enable teachers to determine their students' strategy use and the gender differences concerning strategy use in physics courses. In addition, teachers and/or educators who do not include learning strategy applications in their programs but want to improve the effectiveness of their courses, may wish to review the potential benefits of learning strategies. This is a cross-sectional study because the measurements are taken from groups at a particular point in time (Cohen, Manion, & Morrison, 2007). The situation may have provided different results had another time-frame been chosen. For this reason, it is believed that there has been enough research conducted on this topic. The following suggestions are made for those planning to conduct further studies in this area:

1. The effects of the actual use of learning strategies on achievement in physics could be analyzed in more depth through both qualitative and quantitative research.

2. The relationship between the learning strategies students reported using and those they actually use could be investigated.

3. The effects of gender on learning strategies used in physics education could be investigated using a greater number of studies, and by making comparisons between different cultures.

4. The effects of gender on achievement in physics could be investigated using different assessment instruments (conceptual tests instead of classical achievement tests).

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