ÜNİVERSİTEPARK Bülten

ISSN 2147– 351X (Print)

ÜNİVERSİTEPARK Bülten • Volume 4 • Issue 1-2 • 2015

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To cite this article: Pesman, H. (2015). Interaction of Student Motivation with Contextual Approach and 5e Learning Cycle in Physics. *Üniversitepark Bülten, 4*(1-2), 16-22.

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ÜNİVERSİTEPARK Bülten • Volume 4 • Issue 1–2 • 2015 • pp. 16–22.

Interaction of Student Motivation with Contextual Approach and 5e Learning Cycle in Physics

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Abstract

In this study, it is aimed to investigate in what way students' motivation in physics prior to the treatments of experimental study influences the effects on contextual approach and 5E learning cycle on their achievement. The data comes from a factorial-design-research from which the effects of context-based approach and 5E learning cycle on 11th grade students' achievement in simple electric circuits in a physics class are explored. The Jouhnson-Neyman technique was used for testing the hypothesis of the study. The results are quite interesting. Students with high motivation in physics (above 2.81 out of 5.00) were observed to benefit more from the non-contextual physics instruction, while the students with low motivation in physics (below 1.85 out of 5.00) were observed to benefit more from the contextual physics instruction. Between these boundary values, effects of contextual and non-contextual physics instruction seem not to be different. For the interaction of motivation with 5E learning cycle, no significant interaction could be detected. That is to say, all the students with different levels of motivation in physics benefitted similarly from the 5E learning cycle.

Keywords: Aptitude-treatment interaction, context-based approach, physics education.

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ISSN 2147– 351X © 2015

Introduction

Because students have differing traits, their performances may be different. In other words, there may be an interaction between the learning of students and their differing traits. There is a huge volume of literature on this, known as Aptitude-Treatment-Interaction (Cahen & Linn, 1971). Nonetheless, when a contemporary teaching method is implemented or tested, it is assumed that all the individuals in control or experimental groups are influenced similarly by the treatments.

In order to show evidence for that assumption, homogeneity of regression slopes between the groups is tested (Tabachnick & Fidell, 2007). This is the most important assumption of covariance analysis and it cannot be used if the assumption is violated. In cases where the null hypothesis is not rejected, there is no problem and no evidence found that the students are influenced differently by the treatments. If the null hypothesis is rejected, then there is evidence that students with different traits in each group are differently influenced by the treatments. In other words, the trait demonstrates interaction with the group membership. In such cases, in order to make sense of how the students with differing traits are differently influenced by the treatments, a technique known as Johnson-Neyman is used as an alternative to the covariance analysis (Fraas & Newman, 1997).

In this study, whether or not 11^{th} grade science major students' motivation in physics interacts with a contextual approach and 5E learning cycle is separately investigated by means of the Johnson-Neyman technique. The data comes from a research from which the effects of context-based approach and 5E learning cycle on 11^{th} grade students' achievement in simple electric circuits in a physics class are explored (Pesman & Ozdemir, 2012; Sekerci & Canpolat, 2014; Kartal & Kocabas, 2014). Furthermore, the research design was a factorial design experimental study (Fraenkel, Wallen, & Hyun, 2012) and there were two independent variables: teaching approach and teaching method. The teaching approach was a two-level independent variable: non-contextual and contextual physics instructions. Contextual physics instruction means presenting physics concepts in real-life experiences as they are needed (Millar, 1993). For example, Newton's laws can be studied in the context of traffic safety, concepts related to simple electric circuits can be studied in the context of wiring a house, and electromagnetic radiation can be studied in the context of medical uses of electromagnetic radiations (Millar, 1993). In this study, simple electric circuit concepts were studied in the context of electrical wiring in houses in the contextual groups, while the same concepts were studied with the traditional approach as in the textbooks in the non-contextual approach groups. The teaching method was again a two-level independent variable: Expository teaching and 5E learning cycle. In the expository teaching method, teachers review the previous learning, directly present the content to be taught, solve some exemplary problems and provide students with practice work. In general, students are passive and teachers are more active in expository teaching (Flick, 1995; Taasoobshirazi & Carr, 2008; Sekerci & Canpolat, 2014). The 5E learning cycle is a contemporary teaching method with five steps to be followed: engagement, exploration, explanation, elaboration, and evaluation (Bybee et al., 2006).

Research Question:

- Is there a significant interaction effect between the motivation of 11th grade students in physics and the contextual approach on their achievement in "simple electric circuits"?
- Is there a significant interaction effect between the motivation of 11th grade students in physics and the 5E learning cycle on their achievement in "simple electric circuits"?
- In cases where there are such interaction effects, what are the nature of them?

Hypothesis:

The null hypothesis tested using the Johnson-Neyman technique are as the following:

- The interaction effect between the motivation of 11th grade students towards physics and the contextual approach does not account for some of the variation in their achievement in "simple electric circuits."
- The interaction effect between the motivation of 11th grade students towards physics and the 5E learning cycle method does not account for some of the variation in their achievement in "simple electric circuits."

Methodology

The experimental design was a factorial experimental design (see Figure 1). As seen, there are four groups in the study and the students in Group 1 learned "the simple electric circuits" through the expository teaching method with non-contextual approach, while the students in Group 3 learned the content through the expository teaching with context-based approach. Students in Group 2 learned the content with 5E leaning cycle with non-contextual approach, while the 5E learning cycle with contextual approach was implemented in Group 4.

Figure 1. The Experimental Design (Pesman & Ozdemir, 2012)

		Teaching approach	
		Non-contextual	Contextual
Teaching Method	Traditional	Group 1	Group 3
	Learning cycle	Group 2	Group 4

All of the 11th grade high school science majors were located in Etimesgut, a district of Ankara, the capital of Turkey, and was an accessible population for the research study. A school where the same teacher was teaching at least four 11th grade science major classes was deliberately chosen. Therefore, the sampling method was purposive non-random sampling. Yet, the treatments were assigned to the selected classes randomly. There were 131 students in the sample (72 females and 59 males).

The affective characteristics questionnaire (ACQ) was administered prior to the implementation of the treatments while the simple electric circuits achievement test (SECAT) was administered just after the implementations. In brief, if the students with different levels of motivation in physics were influenced differently by contextual physics instruction was explored in this study. If there was such an interaction, the nature of it was also investigated by means of the Johnson-Neyman technique.

Simple electric circuits achievement test

A test, the SECAT, to assess students' achievement in simple electric circuits was developed by the researcher. It was administered to 12^{th} grade students and the reliability coefficient was calculated as .84. It can be concluded that student achievement scores through the SECAT are sufficiently reliable (Pallant, 2007).

Affective characteristics questionnaire

The ACQ used in this study is an adapted version of the ACQ developed and validated by Abak (2003). The ACQ with high factor loadings in the explanatory factor analysis was used in this study. It is a five-point, Likert-type scale, with seven attitudinal and motivational constructs; situational interest, importance of physics, physics self-efficacy, physics self-concept, achievement motivation, student motivation, and test anxiety. The minimum possible total score for the ACQ is 1.00, while the maximum score is 5.00. The Cronbach Alpha coefficients for pretest and posttest scores were estimated as .92. These values mean that the ACQ scores represent students' attitude and motivation scores in physics at an acceptable level.

Variables

There are four variables in the study. The teaching approach and the teaching method are the independent variables. Both have two levels. For the approach variable, the non-contextual groups were coded as "0" and the contextual groups were coded as "1". For the method variable, the 5E learning cycle groups were coded as "1" and the expository teaching groups were coded as "0". Students' motivation in physics prior to the implementation of the treatments was named as "preaffect". The last variable is "postscore" which represents the students' performance on the SECAT, administered after the implementation of the treatments.

Findings

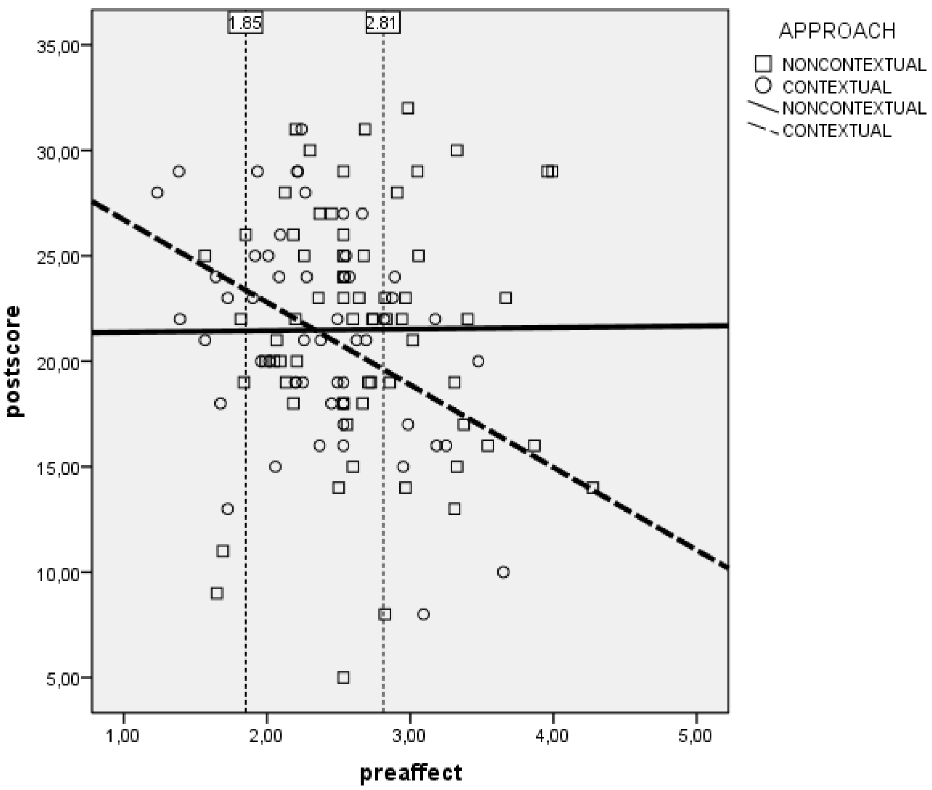
The null hypothesis of the study are tested through a three-step method explained by Fraas and Newman (1997). It is important to emphasize that the Johnson-Neyman technique is used to test the hypothesis of this study; however, what it is and how it is used is not within the scope of this paper. First, the first null hypotheses was tested statistically by means of multiple linear regression. In the analysis, the "postscore" variable was assigned as the dependent variable. The independent variables of the model tested are "approach", "preaffect", and "preaffect*approach". The last variable is computed by multiplying "approach" and "preaffect". It allows the researcher to test whether or not the slopes of the non-contextual and contextual groups' regression lines equal. The results related to the tested regression model are presented in Table 1. There is evidence that slopes of the regression lines for the contextual and non-contextual groups are different ($t=-2.26$; $p<.05$). That is, the null hypothesis is rejected and that the interaction of the students' motivation in physics with the contextual approach accounts for some of the variation (four percent) in their achievement in impulse and momentum.

Table 1. Regression Results for Interaction Effect of “Preaffect” and “Approach” on Post-test Scores on the SECAT

Regression Model Variables	Regression Coefficient	t-value	p value
(Constant)	21.306	7.02	.000
Preaffect*approach	-3.990	-2.26	.026
preaffect	.070	.07	.948
approach	9.316	-2.26	.041
R^2=.064 Adjusted R^2=.041			
Residual Sum of Squares= 3274.50			

The related interaction graph is shown in Figure 2. The second step is to calculate the intersection point at *x*-axis (preaffect). It was calculated as 2.34. The final step is to calculate the boundary points around that intersection point. Thus, the non-significant region at which effects of the contextual or non-contextual approaches are not observed to differ is detected. These upper and lower boundaries were calculated using the Johnson-Neyman technique as explained by Fraas and Newman (1997). They are 1.85 and 2.81.

Figure 2. Scatterplot for Interaction Effect between Students’ Motivation in Physics and Contextual Approach



Consequently, for the students whose pretest ACQ scores are equal to or above 2.81, the contextual approach is statistically more effective than the non-contextual approach. On the other hand, for the students whose pretest ACQ scores are equal to or below 1.85, the non-contextual approach is more effective. For the students whose pretest ACQ scores are between those boundary values, any significant difference between the effects of contextual and non-contextual approaches on the students' achievement could not be observed.

The same steps would have been repeated for the second hypotheses. However, the first step demonstrated that the null hypotheses was not rejected (t=1.00; p=.32). Therefore, there was no evidence that the interaction effect between student motivation in physics prior to the implementations of the treatments and teaching method accounts for a significant amount of variation in students' achievement on the SECAT. Thus, the other steps were not applied. As a result, regardless of the students' motivation, they were observed to similarly benefit from the 5E learning cycle.

Conclusion and Discussion

The context-based instruction is expected to promote students' attitudes to and motivation in science and to improve their learning of science concepts (Bennett, Lubben, & Hogarth, 2007; Taasoobshirazi & Carr, 2008; Baser & Kilinc, 2015). However, this study yields that all students with different traits do not benefit from the context-based instruction in the same way. The Johnson-Neyman technique reveals that the contextual physics instruction is more effective for the students who have low level motivation in physics, while the non-contextual one is more effective for the students who have high level motivation. For students with moderate level motivation in physics, any difference between the effects of contextual and non-contextual physics instruction could not be observed. Therefore, teachers and researchers should pay attention to that point if they are considering applying contextual physics instruction. For the 5E learning cycle, no significant interaction effect on achievement could be observed.

Finally, because contemporary teaching approaches and methods may differently influence students with different traits, such interactions should be investigated by means of the Johnson-Neyman technique. Obviously, such studies may reveal much more information about the effectiveness of teaching approaches and methods taking the individual differences in a classroom into account.

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