

Effects of Formative Assessment in Inquiry-Based Learning on High School Students' Attitudes towards Physics

Simay KOKSALAN
Marmara University

Feral OGAN BEKIROGLU
Marmara University

Abstract: This research study aimed to investigate the effect of formative assessment used in inquiry-based instruction on 10th grade students' attitudes towards physics. For the study, a quasi-experimental with matching only pretest-posttest control group research design was adopted. An answer was searched for the question "Is there a significant difference between the experimental group students who are exposed to formative assessment in inquiry-based instruction and the control group students who are not exposed to formative assessment in inquiry-based learning in terms of their attitudes towards physics?". The participants of the study consisted of 41 students in the 10th grade of a public high school in the spring semester of 2017-2018 academic years. In this study, "Physics-Related Attitudes Scale" was used as quantitative data collection tool. These were applied twice as pre-test and after a five-week treatment period as a post-test to both groups to assess and compare the effectiveness of formative assessment utilized in physics. Quantitative data collection tools were found to having of high reliability. The effect size of the applications (Cohen's d) were large according to the calculations. When the data were analyzed, a significant difference was found between the experimental group and the control group in favor of the experimental group in the final test of Physics-Related Attitudes Scale. The statistical results of the study show that formative assessment in inquiry-based instruction has a positive effect on students' attitudes towards physics course.

Keywords: Inquiry-based instruction, Formative assessment, Physics education, Attitude

Introduction

"If a single word had to be chosen to describe the goals of science educators during the 30-year period that began in the late 1950s, it would have to be inquiry." (DeBoer, 1991). Inquiry-based education has been a part of innovative science teaching for the past ten years (Grob, Holmeier & Labudde, 2017). In the innovative approach of science teaching, inquiry-based learning and assessment methods that should be used in this teaching have created question marks. Inquiry-based learning is incomplete when it is taken in one hand. One of the missing points is about the evaluation method that will be used in education. Nowadays, there are research results that indicate that formative assessment practice can be the most important factor in increasing the academic achievement of all students and especially low success students (Black & Wiliam, 1998). Feedback used in the formative assessment is not a necessary aspect of inquiry-based education but is an important point. Formative assessment is very suitable for inquiry-based learning which aims to develop a scientific understanding of students through a direct interaction with real situations and materials. The importance of inquiry and formative assessment into learning, which have increasing value from day to day, and the results obtained after the application are important for the education system and the teaching to be performed. When the literature is examined, some studies related to inquiry-based learning and formative assessment have been found. However, it is noteworthy that the number of studies, dealing both of them, was very rare. Besides, most of these studies were conducted with the students in primary and secondary schools. It is thought that this study will have an important contribution to the field in the light of the answers to the question about whether the formative assessment used in the inquiry-based learning has an effect on the students' attitudes towards physics. Based on this, a research question was determined as the following:

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- Selection and peer-review under responsibility of the Organizing Committee of the Conference

- Is there a significant difference between the experimental group students who are exposed to formative assessment in inquiry-based learning and the control group are not exposed to formative assessment in inquiry-based learning in terms of the attitudes towards physics?

Methodology

A quasi-experimental approach with pre-test post-test control group (Creswell, 2014) was used as the design of the study. The control group (Group A) and the experimental group (Group B) were selected without random assignment.

Participants and Settings

Participants of the study consisted of 10th grade students studying at an Anatolian High School. One of the 10th grade branches was assigned as a control group and the other one as the experimental group. The study was conducted in five weeks with 41 students. The participants were taught geometrical optics in two hours a week. While guided inquiry-based instruction was applied in both groups, formative assessment was utilized only in the experimental group. In both groups, shadow and plane mirror, refraction, lenses, lens-eye and optical instruments and color concepts were taught as a part of Optics unit. Before the beginning of the implementation process, lesson plans for guided inquiry-based instruction were prepared for each lesson with the contents appropriate for the curriculum acquisition.

Role of the Researcher

In this study, the researcher was also the teacher and the observer during the implementation. While she was a teacher, she stayed away from her role of researcher and approached both groups impartially and equally. She created a classroom environment in both groups to make them comfortable and express their thoughts without hesitation.

Data Collection Tools

Physics-Related Attitudes Scale was used as a data collection tool in this study. In order to determine the attitude towards physics in Günay (2008) study, the term “science” in the TOSRA (Test of Science-Related Attitudes) scale was changed into “physics” and it was called the Physics-Related Attitude Scale. TOSRA was developed by Fraser (1978). The scale consisted of 70 statements in a 5-point Likert scale type. It included the following seven sub-dimensions: social implications of science, normality of scientists, attitude to inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science and career interest in science. The Cronbach Alpha reliability coefficient value of the scale was found as 0.939.

Data Analysis

Descriptive statistics were performed to analyze the data. The effect of formative assessment in inquiry-based learning was examined by using both dependent and independent t-tests. Effect size were also calculated.

Results and Discussion

The effects of formative assessment in inquiry-based instruction on high school students’ attitudes toward physics was investigated in the study. There was no significant difference between the groups’ pre-tests (see Table 1). The findings based on the attitude scale revealed that there were significant increases within the groups pre-and post-tests and between the groups’ post-tests (see Table 2, Table 3 and Table 4).

Table 1. Control and experimental groups' independent sample t test findings for the attitude scale pre-tests

Group	n	\bar{x}	SS	Min. Point	Max. Point	sd	t	p
Control Group (Pre-Test)	21	260.85	26.80					
Experimental Group (Pre-Test)	20	263.55	25.93	70	350	39	-0.327	0.746

According to Table 1, there was no significant difference between the scores obtained from the attitude test of the control and experimental groups ($t_{(39)} = -0.327, p > 0.05$). According to these findings, it was understood that both groups were similar before the implementation.

Table 2. Control group's dependent sample t test findings for the attitude scale

Group	n	\bar{x}	SS	sd	t	p	Cohen's d
Control Group (Pre-Test)	21	260.85	26.80				
Control Group (Post-Test)	21	268.76	23.78	20	-6.53	0.000	0.31

A significant difference was found between the pre-test and post-test scores of the control group students according to Table 2 ($t_{(20)} = -6.53, p < 0.01$). This finding showed that the inquiry-based instruction which was used in the control group made a statistically significant increase in students' attitudes towards physics. When related literature was examined, it was observed that both domestic and international studies supported the findings (Altunsoy, 2008; Gibson & Chase, 2002; Johnson & Cuevas, 2016; Keçeci, 2014; Keçeci & Yıldırım, 2017). In some studies, it was recognized that students had more positive attitudes towards science courses where inquiry-based instruction was implemented.

Table 3. Control and experimental groups' independent sample t test findings for the attitude scale post-tests

Group	n	\bar{x}	SS	sd	t	p	Cohen's d
Experimental Group (Pre-Test)	20	263.55	25.93				
Experimental Group (Post-Test)	20	284.60	24.94	19	-15.24	0.000	0.82

A significant difference was found between the pre-test and post-test scores of the experimental group students according to Table 3 ($t_{(20)} = -15.24, p < 0.01$). This finding showed that formative assessment and inquiry-based instruction applied in the experimental group resulted in a statistically significant increase in students' attitudes towards physics.

Table 4. Control and experimental groups' independent sample t test findings for the attitude scale post-tests

Group	n	\bar{x}	SS	Min. Point	Max. Point	sd	t	p
Control Group (Post-Test)	21	268.76	23.78					
Experimental Group (Post-Test)	20	284.60	24.94	70	350	39	-2.08	0.044

Table 4 supported the finding that formative assessment increased the students' attitudes towards physics ($t_{(39)} = -2.08, p < 0.05$). Ainsworth (2006) addresses the differences between tests and evaluations, and draws attention to the fact that assessments encourage learning, help students develop positive attitudes toward a topic, and provide feedback on what they know and do. After examining the effect of formative assessment used in science

lessons on academic achievement and attitude, Casey (2005) claims that there is a relationship between the use of formative assessment and attitudes towards the usefulness of science. Similar studies support the findings that formative assessment positively affects students' attitudes towards science.

Table 5. Findings on the comparison of the sub-dimensions of the physics-related attitude Scale of control group

Sub-dimensions of Physics-Related Attitude Scale	Control Group Pre-Test Mean	Control Group Post-Test Mean	Control Group Mean Difference	
Social Implications of Physics	40,09	41,19	1,10	
Normality of Physicists	35,58	37,86	2,28	*
Attitude to Inquiry	39,00	40,57	1,57	
Adoption of Scientific Attitudes	40,33	40,71	0,38	
Enjoyment of Physics Lessons	37,91	39,48	1,57	
Leisure Interest in Physics	34,71	35,19	0,48	
Career Interest in Physics	33,23	33,76	0,53	

*: It represents a meaningful difference is the sub-dimensions.

According to the findings shown in Table 5, the control group showed a significant increase only in normality of physicists sub-dimension.

Table 6. Findings on the comparison of the sub-dimensions of the physics-related attitude scale of experimental group

Sub-dimensions of Physics-Related Attitude Scale	Experimental Group Pre-Test Mean	Experimental Group Post-Test Mean	Experimental Group Mean Difference	
Social Implications of Physics	40,85	43,50	2,65	*
Normality of Physicists	37,15	40,05	2,90	*
Attitude to Inquiry	40,15	43,75	3,60	*
Adoption of Scientific Attitudes	42,40	44,35	1,95	*
Enjoyment of Physics Lessons	35,75	40,45	4,70	*
Leisure Interest in Physics	35,10	39,25	4,15	*
Career Interest in Physics	32,15	33,25	1,10	

*: It represents a meaningful difference is the sub-dimensions.

According to Table 6, the experimental group showed a significant increase in almost all the sub-dimensions except for career interest in physics.

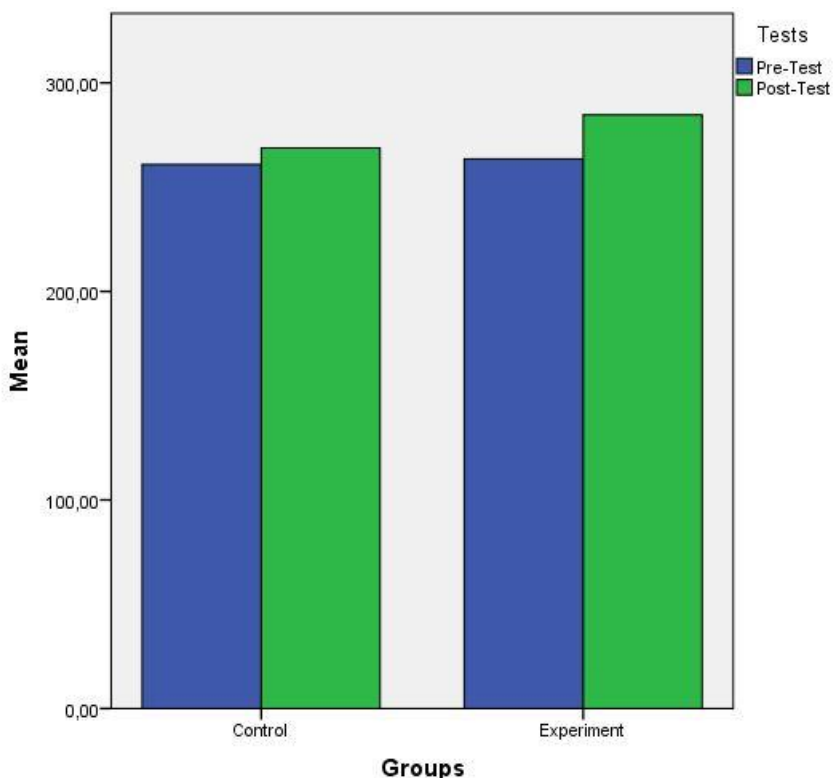


Figure 1. The comparison graph of control and experimental groups' Pre-Test and Post-Test about attitude towards physics

Figure 1 is a summary of all the above findings, where the pre-tests and post-tests of the control and experimental groups were given comparatively. Reviewing the literature indicates that the findings about effects of the formative assessment on students' attitudes are supported by other studies. In some of the studies there is evidence that formative assessment has positive effects on students' attitudes (Ozan, 2017; Tekin, 2010; Yalaki, 2010;). In some other studies, it is mentioned that after using formative assessment practices, students' participation in class has increased, they have found the lesson fun and exciting, students are more interested in the lesson and they are motivated to learn (Bulunuz & Bulunuz, 2013; Cauley & McMillan, 2010; Elmahdi, Al-Hattami & Fawzi, 2018; Günel, 2014; Weurlander, Söderberg, Scheja, Hult & Wernerson, 2012).

Conclusions

This study concludes that inquiry-based instruction has a positive effect on students' attitude towards science. The study also concludes that formative assessment correctly completed and supported in the inquiry-based teaching and learning has more positive effects on students' attitudes towards science.

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Author Information

Simay Koksalan

Marmara University, Goztepe
İstanbul, Turkey

Contact E-mail: simaykoksalan@gmail.com

Feral Ogan Bekiroglu

Marmara University, Goztepe
İstanbul, Turkey