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The Effect of Research-Inquiry Based Activities on the Academic Achievement, Attitudes, and Scientific Process Skills of Students in the Seventh Year Science Course

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Abstract: This quasi-experimental study investigated the effect of research-inquiry based teaching strategies on students' academic achievements (AA), attitudes, and scientific process skills (SPS). The study sample comprised 50 students studying in Grade 7 in a secondary school affiliated to the Ministry of Education (MoE) in Bartın. In this study, experiment and control groups were selected to determine the effect of research-inquiry based teaching strategies. A draft teaching program for the "Reflection and Light Absorption in Mirrors" topic was conducted for three weeks with the experimental group in accordance with the research-inquiry based teaching philosophy and in compliance with the achievements included in the MoE curriculum. In the control group, the regular Classroom Science Course Curriculum was followed. SPS Test, AA Test, and Attitude Scale were employed for the pre and posttests of the experimental and control groups. The test results were analyzed using quantitative analysis methods. The use of research-inquiry based strategies in science courses in research was thus found to have a positive impact on students' AA, attitudes, and SPS.

Keywords: *Achievement; attitude; research-inquiry based activities; scientific process skills.*

The Effect of Research-Inquiry Based Activities on the Academic Achievement, Attitudes, and Scientific Process Skills of Students in the Seventh Year Science Course

Training scientific-minded individuals to be interested in science is a prerequisite for many countries for social and scientific development. Science courses are crucial to capture this change and development. Science is not only just the sum of information about the world but is also a form of research and thinking based on experimental criteria, logical thinking, and questioning (Şad & Arıbaş, 2010).

Technology, which is rapidly evolving, can make its predecessor obsolete in a single day, and hence, it is becoming difficult to keep up with science and technology. A need for individuals who can keep up with this development and change and produce cutting-edge technologies thus exists (Teich, 1977). Individuals who are being educated must be present in learning environments that will increase their curiosity from the very beginning of formal education; contribute to the development of basic knowledge, skills, and thinking patterns; and enable them to think over the causes and consequences of events and predispose them to research and develop their critical thinking skills. To educate people with these qualities and people who have science literacy and enable students to actively participate in learning environments and develop new designs and innovations are among the objectives of teaching programs (Çepni, 2014).

Today, new information is being produced and developed every day. Science education also seeks to train individuals who can investigate and question their world while keeping up with these developments. The research-inquiry based teaching philosophy is one of the important methods used for this purpose. Reports of The National Response Center (NRC) published in 1996, 1997, and 2000 are vital in setting standards on science education, restructuring science education, determining the general framework of inquiry and science teaching, and increasing studies on the use of research-inquiry based teaching philosophies (Finlayson, McLaughlin, Coyle, McCabe, Lovatt, & Van Kampen, 2015; Kaya & Yilmaz, 2016).

In recent years, research related to research-inquiry based learning in science education has been increasing (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991; Edelson, 2001; NRC, 2000; Weiner, 1994; Yıldız, 2012). In these studies, various definitions of research-inquiry based learning can be found. Carin and Bass (2001) defined research-inquiry based learning as “a learning approach where students are presented with a problem situation and follow scientific process steps and collect data for the problem, analyze the data, and interpret their results to solve this problem” (p. 105). Chiappetta & Adams (2004) defined research-inquiry based learning in science education as “an effective process involving scientific thinking, questioning, and structuring of knowledge” (p. 23). In addition, Wallace (1997) defined research-inquiry based learning as “the whole of beliefs and educational practices based on concepts, values, and attitudes that students effectively develop during the learning process of science education” (p. 21).

Science education has an important place in primary education institutions that are compulsory for children aged 6–14 in Turkey. Science education programs are based on a constructivist approach; this approach aims to train individuals with problem-solving skills; help them explore, inquire, and nurture learning desires; understand, use, and develop technology; in achieving self-sufficiency, making their own decisions, and performing their own responsibilities (Yıldırım & Türker Altan, 2017).

Keller (2001) emphasized that the research-inquiry based learning approach should be supported by experiences that will help students construct their own knowledge. Therefore, Keller (2001) highlighted its three important elements: a curriculum that highlights research, a learning environment that supports learning through research, and teachers who can guide students during this process.

Lim (2001) listed the general elements necessary for research-inquiry based learning:

1. Common philosophical and theoretical foundations of research-inquiry based teaching philosophy with a constructivist perspective;
2. Students engaging in the research process for problem-solving;

3. Teaching programs that support the development of high-level thinking and research skills of students;
4. The research process beginning with an original problem situation to encourage students; and
5. The teacher guiding the student throughout the process.

The most important elements of the research-inquiry based learning environment are the curriculum, a learning environment that supports learning through research, teachers who guide students, and the students themselves. It is also vital to develop students' research and high-level thinking skills in the research-inquiry based learning process. This process usually begins with an original problem; however, differences can be observed in the steps of application.

In the extant literature, the application steps of research-inquiry based learning are classified in different ways. Obenchain and Morris (2003) stated that research-inquiry based learning involves steps such as suspicion-curiosity, problem identification, forming a hypothesis, collecting information, analyzing and evaluating the information, testing the hypothesis, and restarting the research.

Several studies examining the effect of research-inquiry based learning have gained importance in the literature in the past years (Carin & Bass, 2001; Çalışkan, 2008; Colburn, 2000; Keller, 2001; Lim, 2001; Llewellyn, 2001; Wallace, 1997). Although there are many studies on the importance of supporters in science education and their use in conjunction with a research-inquiry based learning approach (Bean & Stevens, 2002; Choo, 2007; Harland, 2003; Hmelo-Silver, 2004; Holton & Clarke, 2006; Liang & Gabel, 2005; Zualkernan, 2006), limited studies have been conducted in Turkey (Bay, Gündoğdu, Kaya, Karakaya, Köse, Sönmez, & Taşgın, 2009; Doğanay & Güzel Yüce, 2010; Köroğlu, 2009; Ozan, 2013). When these studies are examined, it is observed that there are no studies for applications in the field of science education. Therefore, it is believed that teachers need sample activities to use supporters in student-centered methods such as research-inquiry based learning. However, the use of the necessary supporting elements with research-inquiry based learning can negatively affect students' academic achievements (AA) (Hmelo-Silver, 2004) and supercognitive awareness (Azevedo & Hadwin, 2005).

Research-inquiry based teaching strategies extend the boundaries of learning from the definition of "information provided by the teacher" to "enable the student to learn directly by researching the activities in which he/she participates." These strategies are the way to ask questions, research and reach information, and find something new about a phenomenon (Yıldırım & Türker Altan, 2017). This study therefore determined the effect of research-inquiry based strategies on AA, attitudes, and scientific process skills (SPS) of Grade 7 students in Turkey.

Research Problem and its Subproblems

This study focuses on the following research problem: Is there a significant difference between the AA, attitude toward the course, and SPS in the pre and posttests scores of the students in the experimental group in which research-inquiry based activities were applied and the students in the control group where the teaching methods were applied according to regular science curriculum?

Further, this study focuses on the following subproblems:

1) Is there a significant difference between the SPS in pre and posttests scores of the students in the experimental group in which research-inquiry based activities were applied and the students in the control group where the teaching methods were applied according to regular science curriculum?

2) Is there a significant difference between the AA pre and posttests scores of the students in the experimental group in which research-inquiry based activities were applied and the students in the control group where the teaching methods were applied according to regular science curriculum?

3) Is there a significant difference between the attitude toward science course pre and posttests scores of the students in the experimental group in which research-inquiry based activities were applied and the students in the control group where the teaching methods were applied according to regular science curriculum?

Literature Review

Science is inherently a research process. While determining the individual success of students in science education, it should be checked whether they have improved not only in terms of their grades but also in their skills of applying knowledge to daily life, problem-solving, critical thinking, and scientific thinking. In the Science–A Process Approach Program developed by the American Association for the Advancement of Science (AAAS), the ability to observe, classify, use numbers, measure, establish space–time relations, communicate, predict/estimate, and draw conclusions are defined as basic SPS. These SPS must be improved for students to perform the research process. Parkinson (1998) stated that science lessons taught in schools should be based on knowledge and process. The aim of science teaching is to improve students' ability to conduct scientific research and use their SPS (Harlen, 1999) because individuals who develop SPS become aware of how a scientific study is conducted and can solve the problems they encounter using scientific methods (Çepni & Çil, 2009). There are many teaching approaches that can be used to equip students with SPS such as research-inquiry based, problem-based, and project-based science teaching. Research-inquiry based science education requires students to take responsibility in the research process and conduct research like scientists. Research skills of students are expected to improve through the use of research-inquiry based activities in science teaching. The skills required to complete a research include SPS (Finlayson et al., 2015). In addition to facilitating learning in science, these skills enable students to take responsibility and participate actively, teach students the ways in which research can be conducted, and aid in increasing their retention of knowledge (Tan & Temiz, 2003). There are many studies in the literature stating that research-inquiry based learning improves SPS (Arslan, 2013; Maral, Oğuz Ünver, & Yürümezoğlu, 2012; Pizzolato, Fazio, & Battaglia, 2014; Ulu & Bayram, 2014; Yalçın, 2014; Yıldırım, 2012; Zacharia, 2003). In their study, Yaşar and Duban (2009) concluded that research-inquiry based learning approach increases the science process skills of Grade 5 elementary school students, makes the lessons fun, and positively affects the students' attitudes toward scientists. Kaya and Yılmaz (2016) examined the achievements and SPS of Grade 7 students with two different methods and found a significant difference in the achievement test and SPS Test scores of the experimental group, where research-inquiry based learning was applied, compared to the control group taught with the traditional method. Karakuyu, Bilgin, and Sürücü (2013) conducted a study on university students and found that the open-ended guided research approach significantly increased AA and SPS compared to the structured and demonstrate–do approach. Bozkurt (2008) concluded in his study that research-inquiry based learning method increases the AA of university students and improves their SPS.

In addition, the development of the affective dimension of science teaching is as important as the cognitive dimension. Therefore, students' attitudes toward science are an essential factor in increasing their success. Attitudes are perceived as one of the most important determinants of human behavior. Thus, measuring attitudes and determining the attitude levels of individuals are crucial for science education as in many other fields (Nartgün, 2002).

Studies show that there is a positive relationship between research-inquiry based learning, one of the student-centered learning approaches, and students' attitudes toward science (Alouf & Bentley, 2003; Ebenezer & Zoller, 1993; Gibson & Chase, 2002; Kahle, 1992; Lord & Orkwiszewski, 2006). As a result of their study with Grade 9 students, Chang and Mao (1999) found that education with research-inquiry based learning significantly increased their achievements compared to the traditional method; in addition, it was stated that positive developments were observed in student behavior and attitudes during the application process. Laipply (2004) examined the effect of research-inquiry based learning on biology self-efficacy beliefs of students and attitudes toward science. Based on the results, it was determined that research-inquiry based learning practices have a positive effect on attitudes toward science and increase students' biology self-efficacy beliefs. Duban (2008) found that research-inquiry based practices conducted with primary school students had a positive effect on their SPS and attitudes toward science lesson. Tessier (2010) examined the relationship between research-inquiry based biology laboratory activities and preservice teachers' attitudes toward science and science teaching; it was concluded that the application positively affected the attitude toward science and science teaching. Alkan Dilbaz, Yelken Yanpar, and Özgelen (2013) investigated the effect of research- inquiry based learning on students' attitude, creativity, and achievement. On the basis of these results, they concluded that research-inquiry based learning increases students' attitude, creativity, and achievement scores. In their study with primary school Grade 7 students, Çalışkan and Turan (2010) concluded that the use of research-inquiry based learning activities in social studies lesson increases students' attitudes toward the lesson compared to traditional approaches.

There are many studies showing that there is a positive relationship between the use of research-inquiry based learning activities in science teaching and student achievement (Bozkurt, 2008; Chang & Mao, 1999; Karakuyu, Bilgin, & Sürücü, 2013; Kaya & Yılmaz, 2016; Tobin, 1986; Ulu & Bayram, 2014; Yalçın, 2014; Yaşar & Duban, 2009; Yıldırım, 2012). When the relevant literature is examined, it is dedcued that there is a significant relationship between AA, attitude, and SPS and research-inquiry based learning. Therefore, it is important to examine the effect of science teaching designed with research-inquiry based activities on AA, attitude, and SPS at every grade level and with different science subjects. In this context, the present study is essential because it contributes to research-inquiry based research conducted in primary education.

Methodology

Model of Research

Quasi-experimental design from quantitative research methods was used in this study. Experimental design is a research design used to determine the cause–effect relationship between variables. The quasi-experimental design can be used in education research where it is difficult to determine schools and classes without sampling (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz, & Demirel, 2020). This research was structured within the scope of an unequalized control group model, which is among the semi-experimental designs.

Sample

The study sample comprised 50 students studying in Grade 7 during the 2018–2019 academic year in a secondary school affiliated to the Ministry of Education. In all, two Grade 7 classes in the selected school were included in the study, and one of the classes was determined as the experimental group.

Data Collection Tools

In the study, “AA Test,” “Attitude Scale,” and “SPS Test” were employed as pre and posttests to collect data. The SPS Test was developed by Smith and Welliver (2006) and adapted to Turkish by Başdağ and Güneş (2006) was used to measure the SPS of the students in the research. The reliability coefficient of the SPS Test was .820 in the original study, .810 in the study from which the test was taken, and .899 in the present study. The scale consists of 13 subdimensions: observation, classification, making inferences, estimation, measurement, data recording, estabslihing number–space relationship, functional description, hypothesizing, experimenting, determining variables, interpretation, and modeling.

The AA Test prepared by Tekin (2019) was used to determine the achievement levels of the students in the subjects taught on “Absorption of Light” in the unit of “Light Absorption and Reflection in Mirrors” (How is light absorbed?, What color are the components of white light?, How and why do we see the colors of objects?, How is solar energy used?). The AA Test consists of 13 multiple choice questions. As a result of the reliability analysis applied for the AA Test, the KR-20 value was determined as .754. The Science Course Attitude Scale developed by Demirbaş and Yağbasan (2005) was used to measure students’ attitudes toward the science course. The scale consists of 44 4-Likert type questions. The reliability of the scale was determined as $\alpha = .875$ for this study.

Implementation

In this study, the SPS Test, AA Test, and Attitude Scale were first applied to the students in the control and experimental groups. After the implementation of the pretests, the participants in the experimental group were informed about the implementation of the research and the process. Students in the control group were not provided with any additional explanation because the courses would be taught following the regular science curriculum. The intervention was made on the “Absorption of Light” topic within the unit “Absorption of Light and Reflection in Mirrors” in the science course of the 2018–2019 academic year. The study was conducted in the spring semester of 2019 and was applied for three weeks in the Science class, 4 h a week. Some photographs of activities with the experimental group are given in Figure 1.

Figure 1

Photos of the Activities Performed with the Experimental Group for Three Weeks.

At the end of the study, the SPS Test, AA Test, and Science Course Attitude Scale were re-applied to the experimental and control groups.

Analysis of Data

The Shapiro–Wilk test was used to check the normality of the distributions of data obtained in the study. The Mann–Whitney U test, Independent samples t-test, Paired samples t-test, and Wilcoxon Marked Signed Test were employed to compare the mean scores of pre and posttests in the experiment and control groups.

While preparing the research data for analysis, it was first examined whether “SPS,” “AA,” and “Attitude” pre and posttests scores showed normal distribution. In cases where the sample size was 30 and below, the Shapiro–Wilk test is preferred, while the Kolmogorov–Smirnov test is preferred in cases where the sample size is 30 and above (McKillup, 2012). Table 1 shows the results of the normality test of the pre and posttests.

Table 1 shows the Shapiro–Wilk test results. According to the results, SPS pretest scores show normal distribution for the experimental and control groups. AA pretest scores show normal distribution for the experimental group and do not show normal distribution for the control group. Attitude Scale pretest scores show normal distribution for the experimental and control groups. SPS posttest scores do not show normal distribution for the experimental group but show it for the control group. AA posttest scores and the experimental and control groups data do not show normal distribution. Attitude posttest scores and data obtained from the experimental and control groups show normal distribution.

Table 1

Normality Distribution of SPS, AA, and Attitude Scale Pre and Posttests Scores

			KS			**SW**		
Test	**Scale**	**Class**	**Statistics**	**df**	**Sig.**	**Statistics**	**df**	**Sig.**
Pretests	SPS	Experimental Group	.131	25	.200	.961	25	.441
		Control Group	.133	25	.200	.946	25	.200
	AA	Experimental Group	.152	25	.142	.937	25	.129
		Control Group	.205	25	.008	.883	25	.008
	Attitude	Experimental Group	.116	25	.200	.974	25	.737
		Control Group	.147	25	.170	.964	25	.498
Posttests	SPS	Experimental Group	.187	25	.024	.779	25	.000
		Control Group	.117	25	.200	.984	25	.952
	AA	Experimental Group	.180	25	.036	.909	25	.029
		Control Group	.156	25	.117	.901	25	.020
	Attitude	Experimental Group	.092	25	.200	.976	25	.789
		Control Group	.130	25	.200	.985	25	.967

Parametric tests were used for total scale scores with normal distribution, while nonparametric tests were used for scores without normal distribution. Pretest scores of “SPS Test,” “AA Test,” and “Attitude Scale” applied to students in the experimental and control groups were evaluated to examine the readiness levels of the two classes.

Findings

Preliminary Review of the Research Data

Pretest scores of “SPS Test,” “AA Test,” and “Attitude Scale” applied to students in the experimental and control groups were evaluated to examine the readiness levels of the two classes.

SPS pretest scores: The results of SPS pretests applied to students in the experimental group before the application of research-inquiry based activities and students in the control group are shown in Table 2.

Table 2

Comparison of SPS Pretest Scores between Groups

Group	N	$\bar{X}$	SS	df	t	p
Experimental Group	25	15.96	.16917	48	−2.215	.032
Control Group	25	20.36	.18170			

According to Table 2, there was a significant difference between SPS pretest scores between the students in the experimental and control groups [t (48) = −2,215, p < .05]. A difference was detected between the arithmetic mean of the groups, and a statistically significant difference was also found (p < .05). Although the experimental and control groups were considered to be similar, there was a significant difference between them in favor of the control group based on the pretest scores.

AA pretest scores: The Mann–Whitney U test results of AA pretests applied to students in the experimental group before the application of research-inquiry based activities and students in the control group are shown in Table 3.

Table 3

Comparison of AA Pretest Scores between Groups

Class	N	Rank Mean	Rank Total	U	W	Z	p
Experimental group	25	23.82	595.50	270.500	595.55	−.827	.408
Control group	25	27.18	679.50				
Total	50						

According to Table 3, there was no significant difference between the students in the experimental and control groups in terms of AA pretest scores (U = 270,500, p > .05). The difference between rank means did not lead to a statistically significant difference between the groups.

Attitude Scale pretest scores: The Independent sample t-test results of Attitude Scale pretests applied to students in the experimental group before the application of research-inquiry based activities and students in the control group are shown in Table 4.

According to Table 4, there was no significant difference between the students in the experimental and control groups in terms of the Attitude Scale pretest scores (t = 1.386, p > .05).

Table 4

Comparison of Attitude Scale Pretest Scores between Groups

Group	N	$\bar{X}$	SS	df	t	p
Experimental group	25	115.28	.20474	48	1.386	.172
Control group	25	112.2	.15384			

As a result of these analyses, it can be deduced that there is no significant difference between academic success and attitudes of the students toward the course, and their readiness levels are equal. However, a significant difference was found between scientific process skill scores, and this difference was in favor of the control group.

Findings Related to Scientific Process Skills

In this section, the difference between SPS posttest scores of students in the experimental and control groups was examined. The results of the Mann–Whitney U test results related to the SPS posttest scores of the students in the experimental and control groups are presented in Table 5.

Table 5

Comparison of SPS Posttest Scores between Groups

Class	N	Row Mean	Row Total	U	W	Z	p
Experimental group	25	21.46	536.50	211.500	536.500	−1.963	.050
Control group	25	29.54	738.50				
Total	50						

As seen in Table 5, no significant difference was found between the SPS posttest scores of the experimental and control groups (U=211.50; p = .05). Students who conducted courses with research-inquiry based teaching strategies obtained higher results in the SPS posttest compared to the pretest, but the posttest scores of the control group were higher, and therefore, more detailed in-group analysis was required to study the effect.

Intragroup comparison of SPS pre and posttests scores in the experimental group: Wilcoxon signed rank test results for the SPS pre and posttests scores in the experimental group are given in Table 6.

Table 6

SPS Pre and Posttests Scores of the Experimental Group

Test Type	N	Row Mean	Row Total	z	Sig.	ŋ2
Neg. Rank	0	.00	.00	−4.373	.000	.44
Poz. Rank	25	13.00	325.00			
Egual	0					
Total	25					

As shown in Table 6, there was a significant difference between the SPS pre and posttests scores of the experimental group ($z = -4.37$, $p < .05$). The extent of the effect of research-inquiry based learning approach on SPS was examined by effect size ($\eta^2 = .44$). Accordingly, it is noticed that approximately 44% of the variance observed in the SPS of the students is explained by the research-inquiry based learning approach. Students in the experimental group participated in the experiments within the scope of research-inquiry based activities and conducted actions that improved their SPS in these experiments. As a result of these activities, students' SPS have improved. To examine the change in SPS of students in depth, the differences in the subdimensions of the scale between the pre and posttests were evaluated.

The results of the Wilcoxon signed rank test conducted for the subdimensions of SPS pre and posttests scores of the experimental group are shown in Table 7.

Table 7

Pre and Posttests SPS Subdimension Scores of the Experimental Group

		n	Row mean	Row total	z	p
Observing	Neg.rank.	0	.000	.000	−4.462	.000
	Pos. rank	25	13.00	325.00		
	Equal	0				
	Total	25				
Classification	Neg. rank	0	.000	.000	−4.187	.000
	Pos. rank	22	11.50	253.00		
	Equal	3				
	Total	25				
Making inference	Neg. rank	0	.000	.000	−4.429	.000
	Pos. rank	25	13.00	325.00		
	Equal	0				
	Total	25				
Estimating	Neg. rank	1	2.50	2.50	−3.950	.000
	Pos. rank	20	11.43	228.50		
	Equal	4				
	Total	25				
Measurement	Neg. rank	0	.000	.000	−.293	.000
	Pos. rank	24	12.50	300.00		
	Equal	1				
	Total	25				
Saving data	Neg. rank	0	.000	.000	−3.992	.000
	Pos. rank	20	10.50	210.00		
	Equal	5				
	Total	25				
Building number–space relationship	Neg. rank	0	.000	.000	−4.221	.000
	Pos. rank	22	11.50	253.00		
	Equal	3				
	Total	25				
Functional identification	Neg. rank	2	8.50	17.00	−3.503	.000
	Pos. rank	18	10.72	193.00		
	Equal	5				
	Total	25				

Table 7 cont.

Setting up hypothesis	Neg. rank	1	5.50	5.50	−3.218	.001
	Pos. rank	14	8.18	114.50		
	Equal	10				
	Total	25				
Experimenting	Neg. rank	0	.000	.000	−3.776	.000
	Pos. rank	18	90.50	171.00		
	Equal	7				
	Total	25				
Determining variables	Neg. rank	0	.000	.000	−3.863	.000
	Pos. rank	19	1000	190.00		
	Equal	6				
	Total	25				
Interpretation	Neg. rank	1	2.00	2.00	−4.062	.000
	Pos. rank	21	11.95	251.00		
	Equal	3				
	Total	25				
Model building	Neg. rank	0	.000	.000	−3.464	.001
	Pos. rank	12	6.50	78.00		
	Equal	13				
	Total	25				

As seen in Table 7, there was a significant difference between all the subdimensions of the SPS pre and posttests of the experimental group ($p < .05$). Thus, the method applied to the experimental group students was observed to affect the SPS.

Intragroup Comparison of SPS Pre and Posttests Scores in the Control Group

Paired samples t-test results for the SPS pre and posttests scores in the control group are given in Table 8.

Table 8

SPS Pre and Posttests Scores of the Control Group

Test Type	**N**	$\bar{X}$	**SS**	**df**	**t**	**Sig.**
Pretest	25	22.4	.17977	24	−6.169	.000
Posttest	25	23.6	.15060			
Total	50					

As seen in Table 8, there was a significant difference between the SPS pre and posttests scores of the control groups ($t = -6.169$, $p < .05$). There was a significant increase in the mean posttest scores (23.6) of the control group students compared to the pretest (22.4).

The results of the Wilcoxon signed rank test conducted for the subdimensions of SPS pre and posttests scores of the control group are shown in Table 9.

Table 9

Pre and Posttests SPS Subdimension Scores of the Control Group

		n	Row Mean	Row Total	z	p
Observation	Neg.rank.	0	.000	.000	−4.582	.000
	Pos. rank	25	13.00	325.00		
	Equal	0				
	Total	25				
Classification	Neg. rank	5	6.20	31.00	-.660	.509
	Pos. rank	7	6.71	47.00		
	Equal	13				
	Total	25				
Making inference	Neg. rank	1	5.50	5.50	−3.570	.000
	Pos. rank	17	9.74	165.50		
	Equal	7				
	Total	25				
Estimating	Neg. rank	19	12.37	235.00	−2.965	.003
	Pos. rank	4	10.25	41.00		
	Equal	2				
	Total	25				
Measurement	Neg. rank	7	10.64	74.50	−.096	.923
	Pos. rank	10	7.85	78.50		
	Equal	8				
	Total	25				
Saving data	Neg. rank	3	3.50	10.50	−1.100	.271
	Pos. rank	5	5.10	25.50		
	Equal	17				
	Total	25				
Building number–space relationship	Neg. rank	5	7.50	37.50	−1.713	.087
	Pos. rank	11	8.95	98.50		
	Equal	9				
	Total	25				
Functional identification	Neg. rank	9	6.94	62.50	−1.255	.210
	Pos. rank	4	7.13	28.50		
	Equal	12				
	Total	25				
Setting up hypothesis	Neg. rank	3	7.00	21.00	−1.941	.052
	Pos. rank	10	7.00	70.00		
	Equal	12				
	Total	25				
Experimenting	Neg. rank	5	7.90	39.50	−1.238	0.216
	Pos. rank	10	8.05	80.50		
	Equal	10				
	Total	25				
Determining variables	Neg. rank	5	5.50	27.50	−1.328	.184
	Pos. rank	8	7.94	63.50		
	Equal	12				
	Total	25				
Interpretation	Neg. rank	11	8.45	93.00	−1.380	.167
	Pos. rank	5	8.60	43.00		
	Equal	9				
	Total	25				
Model building	Neg. rank	9	7.00	63.00	−1.387	.166
	Pos. rank	4	7.00	28.00		
	Equal	12				
	Total	25				

As seen in Table 9, there was a significant difference between the SPS pretest and posttests scores of the control group in terms of the observation, making, inference and estimation subdimensions ($p < .05$). However, there was no significant difference between the other subdimensions of SPS ($p > .05$).

Findings Related to AA Test

In this section, the posttest scores obtained from the AA Test and comparisons between the experimental group and the control group are given. Table 10 examines the difference between the posttest scores of the students in the experimental group and the control group.

Table 10

Comparison of AA Posttest Score

Class	N	Row Mean	Row Total	U	W	Z	Asymp. Sig.	η^2
Experimental group	25	36.74	918.50	31.50	356.50	−5.496	.000	.39
Control group	25	14.26	356.50					
Total	50							

As shown in Table 10, the AA scores of the experimental group differ significantly compared to the control group ($z = -5.496$, $p < .05$). AA scores of students in the experimental group, where a research-inquiry based learning approach was used, increased more for the topic of "Light" compared to the control group. The extent of the effect of research-inquiry based learning approach on success was examined by effect size ($\eta^2 = .36$). Accordingly, it is noticed that approximately 39% of the variance observed in the achievement scores of the students is explained by the research-inquiry based learning approach.

Table 11

AA Pre and Posttests Scores of the Control Group and Experimental Group

	Test Type	N	Row Mean	Row Total	z	Sig.	η2
Experimental Group	Neg. Rank	25	13.00	325.00	-4.389	.000	.44
	Poz. Rank	0	.00	.00			
	Egual	0					
	Total	25					
Control Group	Neg. Rank	21	12.19	256.00	-3.613	.000	.35
	Poz. Rank	2	10.00	20.00			
	Egual	2					
	Total	25					

As shown in Table 11, there was a significant difference between the AA pre and posttests scores of the experimental group ($z = -4.389$, $p < .05$) and control group ($z=-3.613$, $p<.05$). The extent of the effect of research-inquiry based learning approach on AA was examined by effect size ($\eta^2 = .44$). Accordingly, it is noticed that approximately 44% of the variance observed in the AA of the students is explained by the research-inquiry based learning approach. The extent of the effect of regular science curriculum approach on AA was examined by effect size ($\eta^2 = .35$). Accordingly, it is noticed that approximately 39% of the variance observed in the AA of the students is explained by the regular science curriculum approach.

Findings Related to Attitude Toward Science Course

Independent samples t-test was used to compare Attitude Scale posttest scores of students in the experimental and control groups. The results of the t-test for Attitude Scale posttest scores are shown in Table 11.

Table 12

Comparison of Attitude Scale Posttest Scores between the Groups

Test	N	$\bar{X}$	SS	sd (df)	T	p	η2
Experimental group	25	141.96	5.31	48	16.827	.000	.85
Control group	25	114.20	6.30				

As seen in Table 12, there was a significant difference between the Attitude Scale posttest scores of students in the experimental group where research-inquiry based activities were conducted and the students in the control group ($t = 16.827$, $p < .05$). Students' active participation in courses within the scope of research-inquiry based activities may have improved their attitude toward the science course. The extent of the effect of research-inquiry based learning approach on attitude was examined by effect size ($\eta^2 = .85$). Accordingly, it is noticed that approximately 85% of the variance observed in students' attitude scores is explained by the research-inquiry based learning approach.

Table 13

Attitute Pre and Posttests Scores of the Control Group and Experimental Group

	Test Type	N	$\bar{X}$	SS	df	t	Sig.	η2
Experimental Group	Pretest	25	115.36	9.008	24	3.624	.000	.35
	Posttest	25	109.92	6.308				
	Total	25						
Control Group	Pretest	25	109.9	6.75	24	-2.175	.040	.16
	Posttest	25	112.2	6.30				
	Total	25						

As shown in Table 13, there was a significant difference between the Attitute pre and posttests scores of the experimental group ($t = -3.624$, $p < .05$) and control group ($t=--2.175$, $p<.05$). The extent of the effect of research-inquiry based learning approach on Attitute was examined by effect size ($\eta^2 = .35$). Accordingly, it is noticed that approximately 35% of the variance observed in the Attitute of the students is explained by the research-inquiry based learning approach. The extent of the effect of regular science curriculum approach on Attitute was examined by effect size ($\eta^2 = .16$). Accordingly, it is noticed that approximately 16% of the variance observed in the Attitute of the students is explained by the regular science curriculum approach.

Results and Conclusion

This study examined the effect of research-inquiry based activities on student AA, attitudes, and SPS on Grade 7 students of an elementary school enrolled in a science course. First, the effects of research-inquiry based activities on students' AA in the science course were investigated. There was no statistically significant difference between the experimental and control groups in the AA pretest scores. This aspect is an indication that the level of readiness of the students participating in the research is equal. However, there was a statistically significant difference between the posttest scores of the students in the experimental and control groups ($z = -5.496$, $p < .05$). AA of students in the experimental group, where research-inquiry based learning strategies were used, increased more than the students in the control group in terms of the "Light" subject. We can say that individual research and direct experiences of students have a positive impact on AA. Based on these findings, it was determined that research-inquiry based teaching strategies are more effective in increasing the AA and achievement rate. Consequently, the students in the experimental group further increased their AA in the "Light" subject due to the research-inquiry based activities. The effects of research-based learning on the attitudes of students toward the science course were investigated. There was no significant difference between pretest scores in the Attitude Toward Science Course Scale; however, a statistically significant difference was found between the posttest scores ($t = 16.827$, $p < .05$). It can be concluded that students' active participation in courses within the scope of research-inquiry based teaching strategies positively improved their attitude toward the science course. In many studies, it is observed that research-inquiry based learning in science education positively affects students' attitudes and AA in terms of science courses (Aydemir, 2012; Atila, 2012; Çelik, 2012; Davison, 2000; Huber & Moore, 2001; Keller, 2001; Marlow & Ellen, 1999; Schraw & Graham, 1997; Yaşar, 2012). When reform studies in the field of education are investigated in many developed countries such as the United States and the United Kingdom, it is observed that approaches to improve students' AA in science education are emphasized in general. Among the reform movements, the American National Science Education Standards (NRC, 2000) and Project 2061 stand out (Çiftçi & Sünbül, 2005). With these reform movements, the concept of research in science education began to be considered and developed in the early 1960s. First, Biology Science Curriculum Studies (BSCS, 1971) emphasized the importance of scientific research and stated that research in science programs was effective. Rutherford and Ahlgren stated that science teaching should be consistent with the nature of scientific research in their work titled Science for All Americans Association for Advancement of Science (AAAS, 1989). It is also stated by the American National Standards of Science Education (NRC, 2000) that research is a key element in science learning. This aspect can be interpreted as conducting individual research and having direct experiences have a positive impact on the academic success of students.

The effects of research-inquiry based activities on the SPS of students were also investigated in the present study. When SPS scale pretest and final test results were examined between the groups, there was no significant difference between the experimental and control groups. Students in the experimental group who participated in the experiments and conducted activities within the scope of research-inquiry based teaching improved their SPS as a result of the activities; however, this was not reflected as a significant difference in total scores. According to the subdimension scores of the SPS scale (Table 7), students in the experimental group improved in observation, classification, making inference, estimation, measurement, recording data, establishing number–space relationship, functional definition, hypothesis building, experimenting, determining variables, interpretation, and model building dimensions ($p < .05$). In conclusion, research-based teaching activities were more successful for gaining skills such as observation, making inference, estimation, measurement, functional identification, and building hypothesis. Control group students improved in observation, making inference, and estimation subdimensions, while no improvement was observed in classification, measurement, recording data, establishing number–space relationship, functional identification, building hypothesis, experimentation, determining variables, interpretation, and model building subdimensions (Table 9). It can be said that there was no improvement in SPS in general in students taking courses according to regular curriculum. It is also stated by many researchers that research-inquiry based teaching strategies are an effective learning approach for students learning to conduct scientific research like a scientist and in the development of their thinking skills (Colburn, 2000; Geier, Blumenfeld, Marx, Krajcik, Fishman, Soloway& Clay-Cambers, 2008; Wilder & Shuttleworth, 2005; Wilson, Taylor, Kowalski, & Carlson, 2010). It can be concluded that research-inquiry based learning allows students to discover something new while also allowing their creativity to emerge. This result is consistent with the works of Duran and Dökme (2018), Kaya and Yılmaz (2016), Pizzolato et al. (2014), and Tan and Temiz (2003). Science is a course that requires curiosity and research. Students should present their knowledge by discovering science-related information through observations and experiments by conducting research and supporting and interpreting their results with scientific studies. Meaningful learning will only occurr in this way. Therefore, research-inquiry based techniques should be used in science lessons instead of teacher-centered lecturing techniques (Tatar & Kuru, 2006).

For students studying at the primary and secondary education levels, the application of teaching methods to develop skills is as important as the determination and evaluation of SPS. Research-inquiry based teaching strategies are one of the approaches that positively affect students' AA, SPS, and attitudes. Therefore, the importance of active use of these approaches in science teaching programs and lessons is evident.

Recommendations

Research-inquiry based teaching activities, which are frequently employed in science teaching programs, are an approach that improves cognitive and affective skills. This approach, which enables students to actively participate in the lessons, seems to be more effective than many teacher-centered approaches. The activities developed within this method enable students to conduct research and help them meaningfully learn abstract concepts in science education with the help of applications. Thus, meaningful, and permanent learning is achieved in science teaching. Hence, investigating research-inquiry based activities in science classes will contribute to science education and individuals. In this context, it is thought that the study should be expanded and implemented for an entire semester, and the change in students' SPS, AA, and attitudes should be examined in a longitudinal manner. Most of the studies in the extant literature examined only quantitative or qualitative data. In this context, in future studies, it is recommended to expand the process and perform in-depth analyses not only through SPS, AA, and attitude tests but also through observations and interviews. Science teaching with research-inquiry based activities is student-centered. Therefore, the teacher should be able to guide the students in activities such as researching, accessing the right information, and searching for library resources. In this context, teacher education, which is one of the limitations of the study, comes to the forefront. Many teacher-related factors in research-inquiry based approach such as activity preparation skills of teachers, in-service training programs, and the problems teachers encounter in practice should be investigated by researchers in the future.

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