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Guided Inquiry-Based Learning Practices

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Research Article
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Abstract

This study aimed to examine guided inquiry-based learning effect, which is in the "human body systems" unit at the seventh-grade level, on academic achievement and scientific process skills. In this direction, guided inquiry-based learning activities developed by the researchers were applied to the experimental group for 9 weeks. The control group was given lessons as recommended in the curriculum. The study was conducted with 46 seventh-grade students. The experimental group, in which guided inquiry practices designed by the researchers were carried out, consisted of 23 students. The other group formed the control group in which learning was provided by the direct instruction method. Data were obtained by scientific process skills test and academic achievement test. These tests were applied before and after the lessons to both groups. When the data were analyzed, it was seen that the academic achievement test average score of the experimental group was higher when compared to the control group. However, this difference between the mean scores was not statistically significant. It was concluded that there was a statistically significant difference in favor of the experimental group in the mean scores of the science process skills test. Accordingly, it is thought that guided inquiry-based learning can contribute to students' basic scientific process skills, but its contribution to academic success in terms of remembering concepts is not significant.

Keywords: Guided inquiry-based learning, academic achievement, scientific process skills.

Rehberlikli Araştırma-Sorgulamaya Dayalı Öğrenme Uygulamaları

Öz

Bu çalışmada, yedinci sınıf düzeyinde "vücudumuzdaki sistemler" ünitesinde yer alan, rehberlikli araştırma-sorgulamaya dayalı öğrenmenin akademik başarı ve bilimsel süreç becerileri üzerindeki etkisinin incelenmesi amaçlanmıştır. Bu doğrultuda araştırmacılar tarafından geliştirilen rehberlikli araştırma-sorgulama temelli öğrenim aktiviteleri deney grubuna 9 hafta süresince uygulanmıştır. Kontrol grubuna ise müfredatta önerildiği şekilde ders anlatımı yapılmıştır. Araştırma 46 yedinci sınıf öğrencisi ile yürütülmüştür. Araştırmacılar tarafından tasarlanan rehberlikli araştırma-sorgulama uygulamalarının gerçekleştirildiği deney grubunu 23 öğrenci oluşturmuştur. Diğer grup ise doğrudan öğretim yöntemi ile öğrenmenin sağlandığı kontrol grubunu oluşturmuştur. Veriler bilimsel süreç becerileri testi ve akademik başarı testi ile elde edilmiştir. Bu testler her iki gruba da derslerden önce ve sonra uygulanmıştır. Sonuçlar incelendiğinde, deney grubunun akademik başarı testi puan ortalamasının kontrol grubu ile karşılaştırıldığında daha yüksek olduğu görülmüştür. Ancak ortalama puanları arasındaki bu farklılık istatistiksel olarak anlamlı bulunmamıştır. Bilimsel süreç becerileri testinin ortalama puanlarında deney grubu lehine istatistiksel olarak anlamlı bir fark olduğu sonucuna varılmıştır. Buna göre, rehberlikli araştırma-sorgulamaya dayalı öğrenmenin öğrencilerin temel bilimsel süreç becerilerine katkı sağlayabileceği ancak kavramların hatırlanması noktasında akademik başarıya katkısının anlamlı olmadığı düşünülmektedir.

Anahtar kelimeler: Rehberlikli araştırma-sorgulama, akademik başarı, bilimsel süreç becerileri.

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INTRODUCTION

Human beings have been curious about their environment throughout history. As a result of this curiosity, humans have applied to sometimes rational and sometimes irrational ideas in order to have the knowledge. Furthermore, humans have put the new rational ideas, reached through the mind, into certain phases while converting them into knowledge. The encountered rational ideas have been supported, changed or disproved with the newly obtained data and approaches. Thus, many ideas developed which are interconnected and valid (American Association for the Advancement of Science [AAAS], 2009). In order to reach the most accurate one among these ideas that it has developed, human being has made observations, conducted experiments, analyzed the data obtained by using its sensory organs, made inferences and discussed them. As a matter of fact, it has reached scientific knowledge by using these methods. Therefore, in the course of time, it has been deduced that scientific knowledge is not linear, can change in the light of new data, is eclectic and interdisciplinary.

While reaching scientific knowledge in the classroom environment, students must follow the processes scientists used throughout the years. The processes that aim to reach scientific knowledge are expressed as the scientific process in the literature (Tan & Temiz, 2003). The scientific process begins with the question stemming from curiosity and continues with some of the integrated skills such as experimenting, controlling the variables in the experiment, hypothesizing, interpreting data and modelling as it may also include basic steps such as observations, measurements, inferences, classification, estimation and communication (Greenspan, 2016). Naturally, it is requisite to use the methods and strategies that make possible to practice for the students' scientific processes in the classroom environment for students to recognize and use these steps. When the literature is examined, it is seen that the method stating that the students should reach the knowledge on their own through scientific skill processes is expressed as inquiry-based learning (Bell, Smetana, & Binns, 2005; Worth, Duque & Saltiel, 2009).

When the studies conducted are examined, it is seen that there is not only one accepted definition of inquiry (Anderson, 2002; Furtak et al., 2012; Hmelo-Silver, Duncan, & Chinn, 2007; Keys & Bryan, 2001; Kirschner, Sweller, & Clark, 2006; Minner et al., 2010; Newman et al., 2004). According to National Science Education Standards “inquiry into authentic questions generated from student experiences [to be] the central strategy for teaching science” (National Research Council, 1996, p. 31). Linn, Bell & Davis (2004) call for inquiry is the process of willingly attempting to diagnose problems, seeking information, making assumptions, making research plans, generating distinctive alternatives, having critical experiences, using small group discussions and constructive models. Therefore, inquiry-based learning is an approach based on asking questions outside the line of scientific process skills (Crawford, 2007). Considering inquiry-based learning there are two significant results: first, students need genuine scientific practices to learn from their own experiences; second, these practices need to be educative (Çetin & Eymur, 2018). By inquiry-based teaching students could engage in learning (Bacak & Jon Byker, 2021). For avoiding science instruction as textbook based, inquiry-based learning presents students activities like observing, measuring, questioning, investigating, and communicating (Rosenthal, 2018).

According to Banchi & Bell (2005) there are 4 different levels of inquiry-based learning: confirmatory, structured, guided, and open-ended. But planning from the point of view inquiry-based learning seems to be paradoxical (Bykeret al., 2018). Because of the notion that inquiry-based learning happens without much planning or support (Bacak & Jon Byker, 2021).

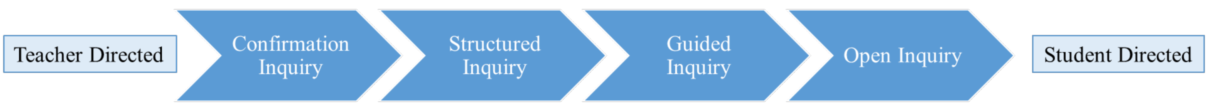

Figure 1. *Phases of Inquiry-Based Learning* (Bacak & Jon Byker, 2021)

The term inquiry refers to at least three separate categories in terms of activities: how students learn, an approach that is used by teachers and what scientists do (Minner, Levy & Century, 2010). Students learn best with their physical and mental activities in environments where they are active (Harlen, 2013). Inquiry enables students to develop their own conceptual learnings and scientific process skills regarding scientific phenomena (Minner, Levy & Century, 2010). For this reason, the inquiry is very appropriate for the nature of learning. In inquiry-based science education students actively participate and enjoy learning and it is very important for students to understand scientific knowledge, develop their knowledge and figure out how scientists work while examining the world (Harlen, 2013; NRC, 1996; Worth et al., 2009). Furthermore teachers should assist the students related to the learning environment by guiding them (Vosniadou, 2003). Besides, inquiry is a way of structuring scientific knowledge, and accordingly, it involves a nonlinear process that supports the continuous development of solutions, key ideas, and strategies (Harlen, 2013). These strategies called as scientific process skills which are used by scientists to gain scientific knowledge (Inter Academy Partnership [IAP], 2010; Keçeci, 2014; National Research Council [NRC], 2000). For this reason, inquiry-based learning is an effective approach in terms of understanding the nature of science (van Uum, Verhoeff & Peeters, 2016).

If we look at inquiry from the approach perspective, learning is another thing to write about. Inquiry is expressed as cyclic since the new information learned in the process will produce new questions (Justice et al., 2002). Inquiry, which is a cyclic process, is also preferred in the subjects or concepts that students have difficulty in learning (IAP, 2010). Since "human body systems" unit subjected to the practice in this study contains many abstract concepts like digestive system, excretory system etc. that cannot be seen by students, it is not easy to learn these concepts by the students. As a matter of fact, there are many studies in the literature revealing that the subjects in this unit are difficult to learn (Nagy, 1953; Prokop & Fanĕoviĕová, 2006; Ramadas & Nair, 1996; Reiss & Tunnicliffe, 2001; Teixeira, 2000). In this context, it is important to visualize and concretize the subjects that are difficult to learn. For students, being active, learning by devoting themselves to the process and reaching knowledge on their own contribute to the concretization of the knowledge (Harlen, 2013; Johnson, 2004; Vosniadou, 2003). Therefore, the difficulties that students have can be eliminated and a significant learning can be achieved by making many concepts and subjects, which are specified as difficult to learn, visual, written and audible by using inquiry-based practices.

In the literature, it is been highlighted that inquiry helps gain knowledge and improve scientific skills (Cairns, 2019; Stout, 2001; Sullivan, 2008; Wu & Hsieh, 2006). Inquiry-based science learning also is a bridge between scientists and students, because in an inquiry-based science learning atmosphere students become engaged class and learn new knowledge like a scientist through inquiry activities. By making inquiry, students can achieve higher levels of understanding (Abdi, 2014). Besides, inquiry-based learning is good at developing students' higher-order thinking skills (Friesen & Jardine, 2009). It is seen in the literature that inquiry-based science helps developing students' higher levels of achievement and scientific process skills. So, what if the academic achievement test is easy and what about the scientific process skills test is basic? The importance of this study is to show up the effect of guided inquiry-based learning practices on gaining basic knowledge and basic scientific skills. On the other side this study's findings can provide information related to the effectiveness of inquiry-based science and gaining basic knowledge and basic scientific skills. And this study seeks to establish empirical support (or refutation) of those inquiry-based practices.

Research Questions

This study aimed to examine inquiry-based learning effect on academic achievement and scientific process skills in in "human body systems" unit which is found at the seventh-grade level. With this aim, the answers were sought for the following questions:

(1) Is there any significant gain in the academic achievement test mean scores of the students in the experimental group in inquiry-based learning?

(2) Is there any significant gain in the scientific process skills test mean scores of the students in the experimental group in inquiry-based learning?

METHOD

Research Design

The research was conducted with pretest-posttest quasi-experimental design with non-equivalent control group (Creswell, 2013) since it contains two groups as control group and experimental group consisting of the students' receiving education in classes. Inquiry was the teaching method in the experimental group. The lessons were processed through the direct instruction method in the control group.

Participants

The study was conducted at a public secondary school in the Central Black Sea Region. The reason behind choosing such a school was the support of the teacher and the school administration on such research and conformity of the physical conditions of the school to the lesson plans. The study group was formed with 46 seventh grade students in two similar classrooms. The permissions for the study was obtained for the students in the two classrooms. A pretest was implemented to determine whether the two groups were similar in terms of academic achievement and scientific process skills before teaching the lessons. One class of the study group was randomly determined as the experimental group (n=23) while the other group was the control group (n=23). There were 10 female and 13 male students in the control group and 7 female and 16 male students in the experimental group. Lessons were conducted by the same teacher in both groups. For the experimental group, inquiry-based learning activities were developed by researchers and in the control group, traditional teaching was followed. The researcher prepared the content of the practice held in lessons in the experimental group in this study. The duty of the teacher in this study is to perform the activities determined by the researcher, i.e., the teacher was not asked to create an activity. Inquiry-based learning practices were carried out for the study group for 7 weeks. Lessons in the control group were examined as prescribed by the curriculum.

Lesson Plans

As an introduction lesson (40+40 minutes) for students, "Mystery Boxes" activity created by Matthews (2006) was performed for understanding the logic of inquiry. In this activity, boxes are an analogy for science. During the activity, students develop skills for discussion, developing a claim, making observation, consensus, and group work.

As it is written in the Turkish national program; digestive system, digestive system organs, physical and chemical digestion, digestive system health, excretory system, excretory system organs, excretory system health, nervous system, nervous system health, central and peripheral nerves system, reflexes, endocrine glands, endocrine glands health, sense organs, sense organs health, sense organs relationships, organ donation and organ transplantation topics were learned from the students.

After the first lesson, the courses were studied by taking into consideration the research planning based learning course planning steps on the Learning Designer web page. In Table 1, the course plan steps, and their contents are given briefly.

Table 1. Course Plan Levels and Contents

Read-Watch-Listen	Collaborate	Discuss	Investigate	Practice	Produce
The students shared the research that they made.	These studies were discussed by group work.	The group discussions were continued with additional questions of the teacher. There was a deeper debate.	The concepts that emerged in the discussions were investigated.	Concepts, analogy, Anatomy 4D were applied with activities such as.	Using the concepts, products such as model and concept maps were created.

Sample Lesson Plan (Digestive System Lesson-1 (2 Lessons 40 + 40 minutes)

Read-Watch-Listen (5 minutes): The students came to class with interesting news / information as instructed in the previous lesson. They shared interesting news / information with their friends. Here, the teacher left open the way to find news on the internet for some students not to come with news (or the teacher could come up with some interesting news or information in his hand). Alternatively, this interesting information can also be asked to students in question form. The teacher asked the students "What is the most interesting information for you?" and received their opinions.

Collaborate (5 minutes): Then, the students were divided into groups of 3-4 people to identify and list the digestive system organs by sharing their digestive organs, digestive systems, and experiences.

Discuss (15 minutes): The students discussed with each other to make definitions and lists in the group. The teacher played a guiding role in the definitions obtained in the discussion and asked some guiding questions when necessary.

Investigate (15 minutes): After the group listed the digestive system organs, they searched the information about the digestive system organs from the book and the internet (web pages that could be searched by the researcher could be given to the students by the researcher as QR codes. However, in this study, students wanted to do the research themselves and not be restricted. Therefore, QR codes are not used). The resource books that the groups would benefit from were made available at their desks at the beginning of the lesson. In each lesson, books were available at the students' desks to be used as secondary sources with the internet. Then they shared the information they wanted to share in the group. After sharing the information, students were asked to find “the human body” worksheet of the Anatomy 4D program on the internet. However, although the students could not get print outs, the worksheet was obtained from the internet. If there is a possibility to print / print out, students may also be asked to take their own printouts.

Practice (10 minutes): The human body worksheet of the Anatomy 4D program was given to each group (Figure 1). All members of the groups practiced the locations and functions of the digestive system organs in virtual reality.

Produce (30 minutes): The students prepared and presented a concept map by drawing by hand (they may be asked to create a concept map by using programs such as lucidchart, popplet, coggle, scratch if computer class is available). While creating the concept map, the students were reminded that the shapes of the organs of the system could be included. Before drawing, the students drew the shapes they examined in the required parts of the concept map (the students could print these and paste). Alternatively, if every student could access computers, students can bring shapes the organs to the classroom with flash memory and they can use the programs such as lucidchart, popplet, coggle and scratch to create a concept map.

The students were divided into different groups (every lesson teacher has made different groups) for the next lesson and the students were asked to come to the next lesson by modeling all the digestive organs they learned with play dough. The reason for planning the groups in advance was to inform the students about the groups to adjust the seating arrangement of the groups before the lesson and thus to save time. Groups for this and every subsequent lesson are planned and notified to students

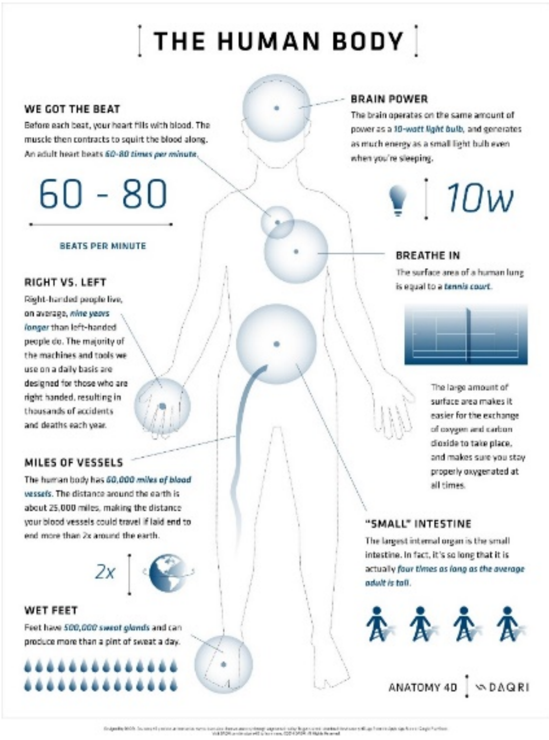

Figure 2. *The Human Body Worksheet* [1]

Data Collection Process

Inquiry-based learning practices were carried out to the study group for 7 weeks within the scope of the human body systems unit. While preparing this study plan, attention was paid to complete the achievements within the time recommended in the program. All data collection tools and week-by-week lesson plans applied to both the experimental and control groups are given in Table 2.

[1] https://www.commonsense.org/education/app/anatomy-4d

Table 2. Data Collection Tools, and Week-By-Week Lesson Plans Applied to Both the Experimental and Control Groups

Implementation Week	Experimental Group (Lesson Duration)	Control Group (Lesson Duration)
Week 1	Pretest (academic achievement test) application Magic Boxes (2)	Pretest (academic achievement test) application
Week 2	Digestive System Lesson-1 (2) Digestive System Lesson-2 (2)	Digestive System (4)
Week 3	Digestive System Lesson-3 (2) Excretory System Lesson-1 (2)	Digestive System (2) Excretory System (2)
Week 4	Excretory System Lesson-2 (2) Supervisory and Regulatory Systems Lesson-1 (2)	Excretory System (2) Supervisory and Regulatory Systems (2)
Week 5	Supervisory and Regulatory Systems Lesson-2 (2) Supervisory and Regulatory Systems Lesson-3 (2)	Supervisory and Regulatory Systems (4)
Week 6	Supervisory and Regulatory Systems Lesson-4 (2) Sense Organs Lesson-1 (2)	Supervisory and Regulatory Systems (2) Sense Organs (2)
Week 7	Sense Organs Lesson-2 (2) Sense Organs Lesson-3 (2)	Sense Organs (4)
Week 8	Sense Organs Lesson-4 (2) Organ Donation and Transplantation Lesson-1 (2)	Sense Organs (2) Organ Donation and Transplantation (2)
Week 9	Posttest (academic achievement test) application Semi-Structured Interview	Posttest (academic achievement test) application

Data Collection Tools

The academic achievement test

To measure the academic achievements of the students regarding the "Human body systems" unit, the Academic Achievement Test developed by Yerlikaya and Güneş (2017) was used. The mean item difficulty index (p) of the academic achievement test was found to be 0.66 and the values of the items difficulty indexes varied between 0,37 and 0,81. With this the mean item discrimination index (r) was detected as 0.61. and the values of the discrimination power indexes varied between 0,40 and 0,89. For internal validity, KR-20 value was examined and detected as 0.90. In other words, it can be stated that the academic achievement test developed by Yerlikaya and Güneş (2017) and consisting of 4 options and 45 items is a test that is easy and can distinguish between the cognizant and incognizant, comply with acquisitions and purpose and have sufficient validity and reliability.

The scientific process skills test

This test was developed by Okey, Wise and Burns and it consists of 36 items which were translated into Turkish by Özkan, Aşkan and Geban (1992). The form was applied to 8th grade and reduced to 28 items because of the validity and reliability (Aydoğdu, 2006). In the study conducted by Aydoğdu (2006), the validity and reliability study of the test was conducted with 336 7th grade students within the scope of making it suitable to the cognitive level of the 7th grade students and the adaptation of the test to the 7th grade level was performed. The reliability of the test, which was adapted to seventh grades, was calculated as 081. As a result of this adaptation, a reliable Scientific Process Skills Test consisting of 4 options and 26 items was obtained. Response categories of this test is dichotomous (0 or 1). In this study, the data related to scientific process skills were obtained with the scale adapted by Aydoğdu to seventh grades.

Data Analysis

Within the scope of the study, as pretest and posttest, academic achievement test and scientific process skills test were applied to both groups. While scoring the tests, correct answers were given 1, wrong answers were given 0 and they were proportioned in a way that the total score was 100. While the lowest score is 0 that the students can get from the academic achievement test and scientific process skills test, the highest score is 100. When evaluating the scores obtained from the tests, the mean values of experimental and control groups were analyzed statistically. During this analysis, the data obtained were analyzed using the SPSS package program and Microsoft Excel.

Determining whether the data is normally distributed is important for choosing the statistical method to be used. For this reason, the distributions of the data were examined first. Since the study group was smaller than 50, the results of the Shapiro-Wilk test were examined to test whether the data were appropriate for the normal distribution. The Shapiro Wilk values regarding the academic achievement test and scientific process skills test of both experimental and control groups are given in Table 3.

Table 3. Shapiro-Wilk Values for Experimental and Control Groups (*p*)

	Academic Achievement Test	Scientific Process Skills Test
Experimental Group (pre-test)	0,44	0,017*
Experimental Group (post-test)	0,184	0,126
Control Group (pre-test)	0,299	0,699
Control Group (post-test)	0,270	0,706

* $p < .05$ means non-normal distribution

When Table 3 is examined, it is seen that the scientific process skills test of the experimental group shows non-normal distribution before the practice and the distribution of all other data is normal. While parametric tests were used in the data showing normal distribution, non-parametric tests were used in the data showing non-normal distribution. Table 4 shows the tests used when analyzing the data.

Table 4. Distributions of Tests Applied to Data Obtained from Experimental and Control Groups

	Pre-test	Post-test
Academic achievement test	independent samples t-test	independent samples t-test
Scientific process skills	Mann-Whitney U test	independent samples t-test

While analyzing the data in this study, Mann-Whitney U test was used for non-parametric tests for unrelated analyses and in cases with normal distribution (all other cases), t-test was used for independent samples for unrelated analyzes from parametric tests (Table 4). The Mann-Whitney U test, which is one of the tests that can be used if the data cannot meet the normal distribution assumption, is the non-parametric equivalent of the t-test for independent samples used to determine the differences between two averages (Büyüköztürk, 2011). The t-test for independent samples is a parametric test used to test the difference between two independent means (Büyüköztürk, 2011). In other words, for this test to be applied, the data must be in accordance with the normal distribution (Büyüköztürk et al., 2010).

Findings

The Academic Achievement Test Results

In figure 3 and 4 pre and post test results of the academic achievement test of control and experiment groups are given.

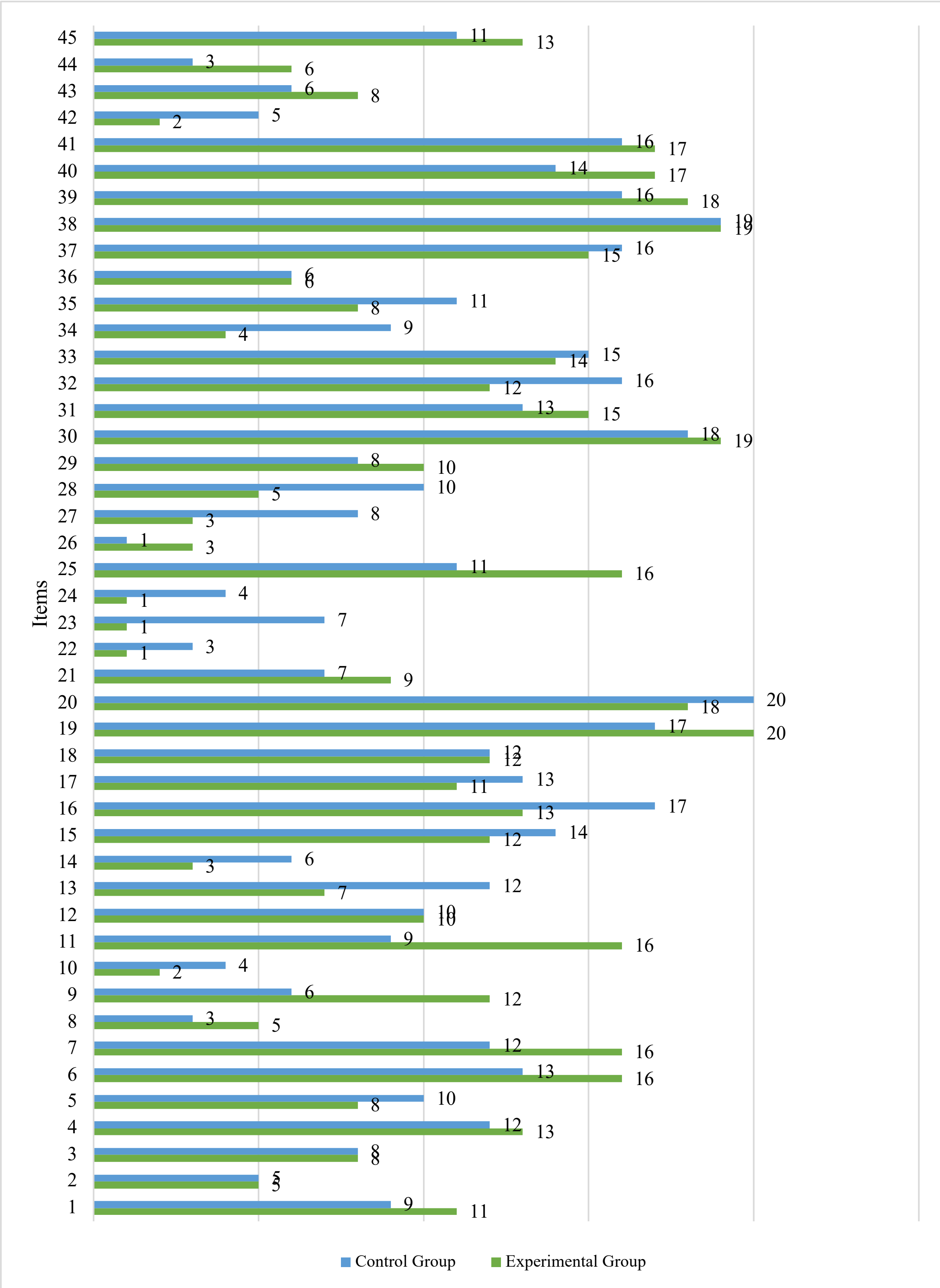

Figure 3. *Numbers of Student Giving Correct Answers to Academic Achievement Test (Pre-Test)*

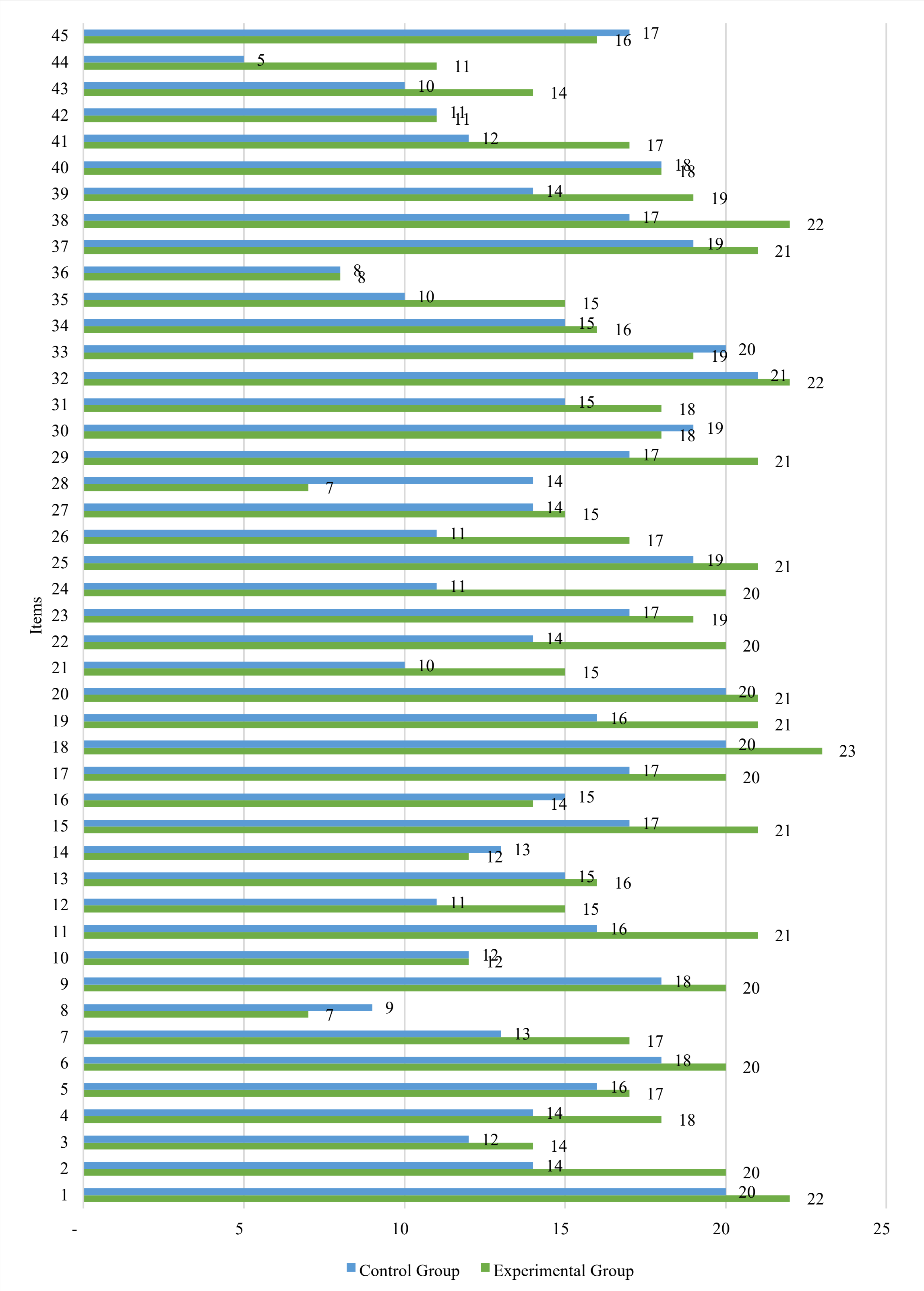

Figure 4. *Numbers of Student Giving Correct Answers to Academic Achievement Test (Post-Test)*

Academic achievement test means of the experimental and control group students in pre-test

Table 5. Independent Samples T-Test Findings of the Academic Achievement Test Means of Experimental and Control Group Students for Pre-Test

	N	x̄	S	sd	t	*p*
Experimental Group	23	44.61	9.70	44	-0.08	.93
Control Group	23	44.87	11.99			

Before the practice, the academic achievement test mean of the experimental group was 44.61; academic achievement test arithmetic mean of the control group was detected as 44.87. The independent samples t-test was used to determine whether there was a statistically significant difference between the academic achievement test means of the experimental and control group before the practice. According to the results of the t-test, there was no statistically significant difference between the academic achievement test means of the experimental and control groups before the practice (t (44) =-0.08, *p*>.05) (Table 5). According to this result, it can be stated that there is no difference between the groups in terms of academic achievement before the practice.

Academic achievement test means of the experimental and control group students in post-test

Table 6. Independent Samples t-Test Findings of the Academic Achievement Test Means of Experimental and Control Group Students for Post-Test

	N	x̄	S	Sd	t	*p*
Experimental Group	23	74.52	16.59	44	1.95	.06
Control Group	23	64.17	19.32			

After the practice, the academic achievement test mean of the experimental group was 74.52; the academic achievement test mean of the control group was detected as 64.17. Therefore, the mean value belonging to the academic achievement test of the experimental group is higher after the practice. The independent samples t-test was used to determine whether there was a statistically significant difference between the academic achievement test means of the experimental and control group after the practice. According to the results of this test, there was no statistically significant difference between the academic achievement test means of the experimental and control groups (t (44) = 1,95, *p* >.05) (Table 6).

Scientific Process Skills Test Results

In figure 5 and 6 pre and post test results of the scientific process skills test of control and experiment groups are given.

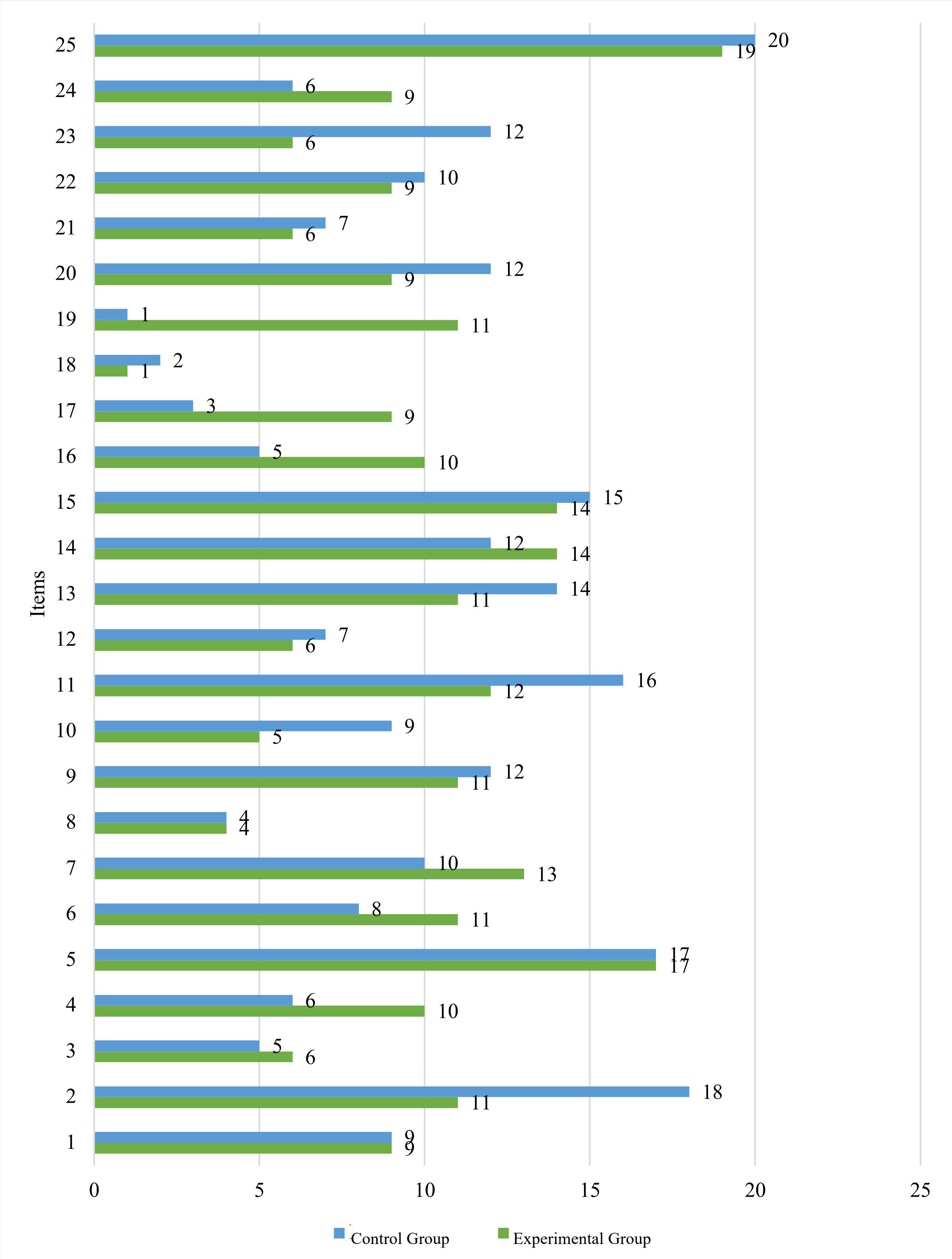

Figure 5. *Numbers of Student Giving Correct Answers to Scientific Process Skills Test (Pre-Test)*

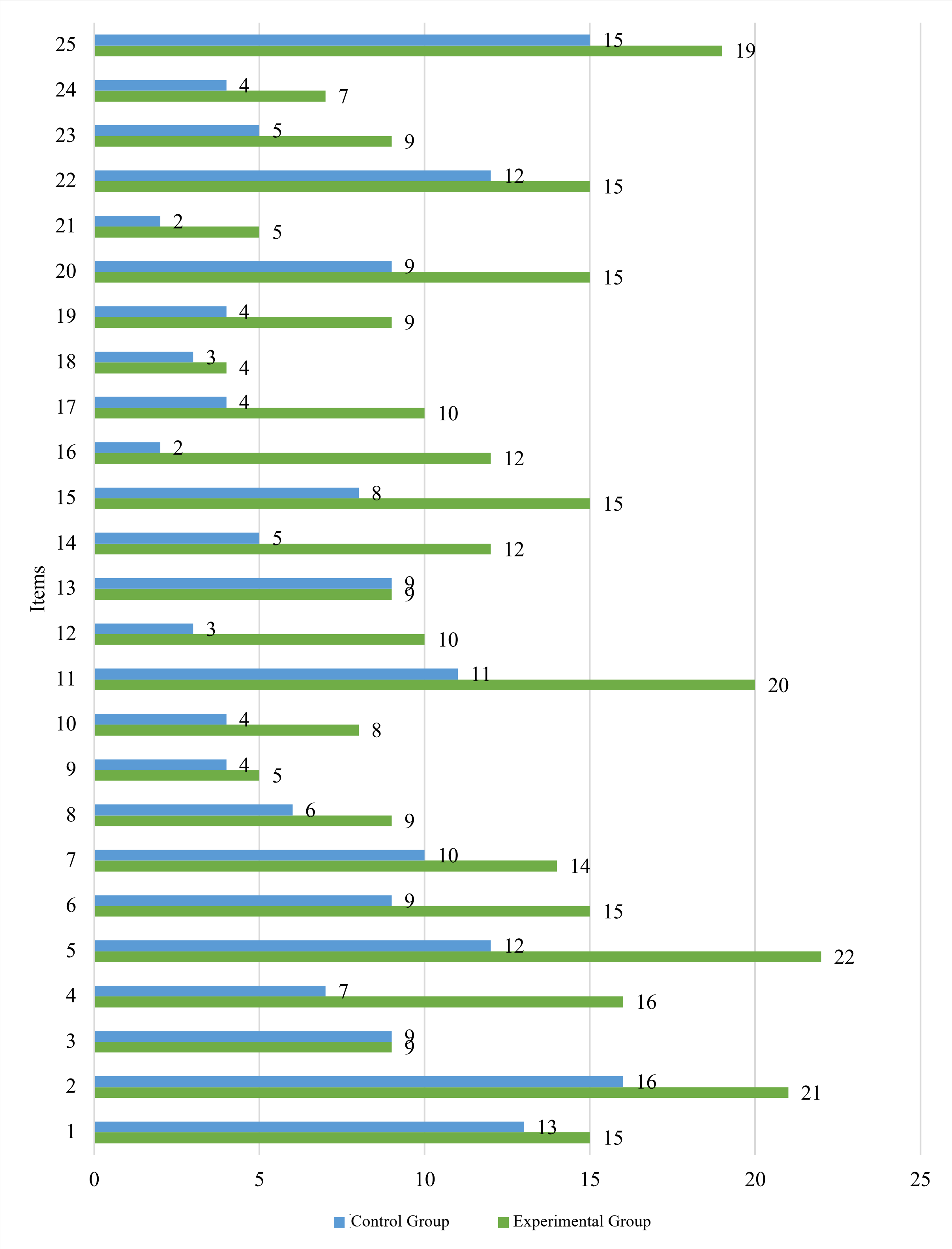

Figure 6. *Numbers of Student Giving Correct Answers to Scientific Process Skills Test (Post-Test)*

Scientific process skills test means of the experimental and control group students in the pre-test

Table 7. Mann-Whitney U Test Findings of the Scientific Process Skills Test Means of Experimental and Control Group Students for Pre-Test

	N	Sum of Ranks	Mean Rank	U	Z	*p*
Experimental Group	23	22.72	552.50	246.50	-0.40	.70
Control Group	23	24.28	558.50			

Before the practice, the scientific process skills test mean of the experimental group was 42.261; the scientific process skills test mean of the control group was detected as 42.09. Mann-Whitney U test was used to determine whether there was a statistically significant difference between the scientific process skills test means of the experimental and control group before the practice. According to the results of the Mann-Whitney U test, there was no statistically significant difference between the academic achievement test means of the experimental and control groups before the practice (U = 246.50, $p>.05$) (Table 7). According to this result, it can be stated that there is no difference between the groups in terms of scientific process skills before practice.

Scientific process skills test means of the experimental and control group students in post-test

Table 8. Independent-Samples T-Test Test Findings of the Scientific Process Skills Test Means of Experimental and Control Group Students for Post-Test

	N	x̄	S	sd	t	*p*
Experimental Group	23	53.04	16.10	44	4.74	.00
Control Group	23	32.35	13.43			

The experimental group has a higher mean value of the scientific process skills test after the application. After the practice, the scientific process skills mean of the experimental group was 53.04; the scientific process skills mean of the control group was detected as 32.35. Therefore, the mean value belonging to the scientific process skills test of the experimental group is higher after the practice. The independent samples t-test was used to determine whether there was a statistically significant difference between the scientific process skills test means of the experimental and control group after the practice. According to the results of this test, there was a statistically significant difference between the scientific process skills test means of the experimental and control groups ($t(44) = 4.74$, $p<.05$) (Table 8). The scientific process skills test scores of the experimental group are statistically and significantly higher than the scores of the control group.

Discussion & Conclusion

In this study, an easy academic achievement test Yerlikaya and Güneş (2017) was performed to determine inquiry practices' effects on academic achievement. It was determined that the experimental groups' academic achievement was increased after the practice. It draws attention that this increase is more than the group in which lessons were taught through the direct instruction method. However, it was determined that this increase between the two groups was not statistically significant. The result of this study matches some studies' results in the literature (Chung, 2004; Miller, 2014; Poderoso, 2013; Witt & Ulmer, 2014). According to Miller (2014), inquiry led to an increase in the academic achievement means; however, this increase was not statistically significant. Witt & Ulmer (2014) stated that seventh graders academic achievement scores are not statistically different between control and experimental group. Poderoso (2013) found no evidence that emphasizing inquiry-based science program is associated with significant differences in mean science benchmark achievement scores. Chung (2004) found there were no statistical significant differences looking at achievement test scores. van Riesen et al. (2018) has found no evidence that inquiry-based learning is effective for learning conceptual knowledge. On the contrary these findings, it was concluded in some studies that inquiry had a statistically significant, positive relationship with academic achievement (e.g., Cairns, 2019). It is thought that this result obtained in the study conducted may have more than one reason. One of these reasons may be related to the fact that the achievement test used in this study was an easy test and this could be caused an increase in the academic achievement levels of both groups. Because inquiry-based learning is good at developing students' higher-order thinking skills (Friesen & Jardine, 2009). Therefore, the same rate of the increases in both groups in the achievement test might result from the fact that the scale was easy. Another reason may be the use of guided inquiry-based learning method in this study. Therefore, it is thought that conducting the same study with open-ended inquiry practice will lead to a higher increase in academic achievement. Students must master inquiry (guided to open-ended) step-by-step (Bell, Smetana, & Binns, 2005). However, the students were in a guided inquiry-based learning environment for the first time. Another issue to take into consideration about the reason is that the inquiry activities in this study were carried out during only one unit. In other words, the reason for not obtaining a significant difference between the experimental and control group after the instruction process in academic achievement test means may be due to the limitation of the inquiry practice with only one unit. In fact, Harlen (2013) states that inquiry is a long process. Newman et al. (2004) stated that a school year would not be sufficient for students to understand all the details of the subject. Beyond these van Riesen et al. (2018, 2022) conducted studies about the inquiry-based learning. Even in their first study (2018) they couldn't reach a significant difference between the groups according to conceptual knowledge gain, their last study shows that inquiry-based learning helps students to gain conceptual knowledge. When all these findings are taken into consideration, it is seen that a longer time is needed to fully understand the concepts and skills learned. In addition, all these reasons, it is thought that the additional courses privately taken by the students in both experimental and control groups outside the school may have influenced this result. Beyond all these according to Burris & Garton (2007) "while students may have a deeper understanding of the material, that understanding is not represented at a content knowledge level". So, if an academic test is consisted of basic concepts and easy, there could be no difference found looking at the students' scores. But if it considered student-oriented learning, deeper understanding and reaching a knowledge like a scientist, inquiry-based science should be used by teachers as an approach. Even if it is a long process, meaningful learning can be reachable by using inquiry-based science.

The scientific process skills test was used in this study to determine the basic scientific process skills in a guided inquiry-based practices. It was determined that while the groups were initially homogenous in terms of the scientific process skills test, the experimental group where inquiry-based practices were performed showed statistically significant difference after the unit was completed. In other words, this inquiry-based practice positively developed the scientific process skills. In some studies, in the literature, it is also stated that the inquiry environment positively affects scientific process skills (Stout, 2001; Sullivan, 2008; Wu & Hsieh, 2006). In addition to recognizing the scientific process skills at the beginning and during the process with various activities on the inquiry environment, the use of these skills by the students during the practice may be the reason of this significant increase on the scientific process skills test environments. Therefore, it can be said that the use of scientific process skills was developed through various activities carried out on the inquiry-based learning environment. Longo (2012) detected a significant difference in favor of the group where the lesson was taught with the inquiry on the scientific process skills test environments. Considering these skills, it is seen that some studies worked separately about the skills. Dori, Zohar, Fischer-Shachor, Kohan-Mass & Carmi (2018) find that question posing, and graphing skills are improving in the inquiry. Wu & Hsieh (2006) studied about some skills, and they find out the inquiry learning environment develops students' causal relationships determining, defining the duration of reasoning, and data using as argument skills. At the same time, some studies stated that there is an improvement in some students' skills depends on the level of inquiry (Arnold, Kremer, & Mayer, 2014; Kuhn, 2016; Zimmerman, 2007).

According to all these results, training can be given to teachers about inquiry at all levels and studies can be conducted to design practices together with students. Because deeper understanding and reaching knowledge like a scientist are crucial in science classrooms. So, inquiry-based science should be used as an approach and teaching strategy by teachers for making students active learners. Also, without time and content limitation, students' areas of interest can be determined and practices in which students can create their own contents and teachers only guide them can be planned.

Statements of Publication Ethics

We obey the principles of publication ethics. Our ethics committee date is 15.07.2016, the document number is 2016-102.

Researchers' Contribution Rate

The first author was writer of the doctoral thesis, and the second author is thesis advisor for the first author. The first author was scanned published works about the topic, gathered the data, analyzed the data, finds the results, and discussed the results under the supervision of the second author.

Conflict of Interest

There is no conflict of interest in this study.

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REFERENCES

Abdi, A. (2014). The effect of inquiry-based learning method on students' academic achievement in science course. *Universal Journal of Educational Research 2*(1), 37-41

American Association for the Advancement of Science. (2009). Benchmarks for science literacy. http://www.project2061.org/publications/bsl/online/index.php

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry?. *Journal of Science Teacher Education, 13*(1), 1–12.

Arnold, J. C., Kremer, K., & Mayer, J. (2014). Understanding students' experiments—what kind of support do they need in inquiry tasks? *International Journal of Science Education, 36*(16), 2719–2749.

Aydoğdu, B. (2006). *İlköğretim fen ve teknoloji dersinde bilimsel süreç becerilerini etkileyen değişkenlerin belirlenmesi [Identification of variables effecting science process skills in primary science and technology course]*. Master's Dissertation, Dokuz Eylül University.

Bacak, J., & Jon Byker, E. (2021). Moving from levels of inquiry to the flexible phases of inquiry theory: a literature review of inquiry-based teacher education. *Journal of Teacher Education and Educators, 10*(2), 255-271.

Banchi, H., & Bell, R. (2005). The many levels of inquiry. *Science and Children, 46*(2), 26–29.

Bell, R. L., Smetana, L., & Binns, I. (2005). Simplifying inquiry instruction. *The Science Teacher, 72*(7), 30–33.

Burris, S., & Garton, B. L. (2007). Effect of instructional strategy on critical thinking and content knowledge: Using problem-based learning in the secondary classroom. *Journal of Agricultural Education, 48*(1), 106-116.

Büyüköztürk, Ş. (2011). *Sosyal bilimler için veri analizi el kitabı [Data analysis handbook for social sciences]*. Pegem Yayıncılık.

Büyüköztürk, Ş., Çokluk, Ö., & Köklü, N. (2010). *Sosyal bilimler için istatistik* [Statistics for social sciences] (6. Basım). Pegem Yayıncılık

Byker, E.J., Putman, S. M., Polly, D., & Handler, L. (2018). Modeling TPACK for the development of educators' self-efficacy. In Charles B. Hodges' (Ed.), *Self-efficacy in Instructional Technology Contexts*. Springer International.

Cairns, D. (2019). Investigating the relationship between instructional practices and science achievement in an inquiry-based learning environment. *International Journal of Science Education*, 1-23.

Crawford, B. A. (2007). Learning to teach science as inquiry in the rough and tumble of practice. *Journal of Research in Science Teaching, 44*(4), 613 – 642.

Creswell, J.W. (2003). *Research design – qualitative, quantitative and mixed method approaches* (2nd ed.). Sage Publications.

Çetin, P. S., & Eymur, G. (2018). Beyond the writing aspect of argument-driven inquiry: investigating students' cognitive and affective expectations. *Bartın University Journal of Faculty of Education, 7*(1), 94-110. DOI: 10.14686/buefad.376998

Dori, Y. J., Zohar, A., Fischer-Shachor, D., Kohan-Mass, J., & Carmi, M. (2018). Gender-fair assessment of young, gifted students' scientific thinking skills. *International Journal of Science Education, 40*(6), 1-26.

Friesen, S., & Jardine, D. (2009). *21st century learning and learners*. Galileo Educational Network.

Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and quasi-experimental studies of inquiry-based science teaching a meta-analysis. *Review of Educational Research, 82*(3), 300–329.

Greenspan, Y. F. (2016). *A Guide to Teaching Elementary Science Ten Easy Steps*. Sense Publishers Rotterdam.

Harlen, W. (2013). Inquiry-based learning in science and mathematics. *Rewiev of Science, Mathematics and ICT Education, 7*(2), 9–33.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist, 42*(2), 99–107.

Inter Academy Partnership. (2010). Taking IBSE into secondary education report. http://www.interacademies.org/File.aspx?id=15174

Johnson, K. E. (2004). *Middle school science inquiry: connecting experiences and beliefs to practice*. Doctorate Dissertation, University of Colorado.

Justice, C., Warry, W., Cuneo, C., Inglis, S., Miller, S., Rice, J., & Sammon, S. (2002). *A grammar for inquiry: linking goals and methods in a collaboratively taught social sciences inquiry course*. Special Publication of the Society for Teaching and Learning in Higher Education and McGraw-Hill Ryerson.

Keçeci, G. (2014). *Araştırma ve sorgulamaya dayalı fen öğretiminin öğrencilerin bilimsel süreç becerilerine ve tutumlarına etkisi [The effects of inquiry-based science teaching on students' science process skills and attitudes]*. Doctorate Dissertation, Fırat Üniversitesi.

Keys, C. W., & Bryan, L. A. (2001). Co-constructing inquiry-based science with teachers: essential research for lasting reform. *Journal of Research in Science Teaching, 38*(6), 631–645.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the Failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86.

Kuhn, D. (2016). What do young science students need to learn about variables? *Science Education, 100*(2), 392–403.

Linn, M. C., Davis, E. A., & Bell, P. (Eds.). (2004). *Internet environments for science education.* Lawrence Erlbaum Associates Publishers.

Longo, C. M. (2012). *Effects of an inquiry-based science program on critical thinking, science process skills, creativity, and science fair achievement of middle school students*. Doctorate Dissertation, Western Connecticut State University.

Matthews, B. (2006). Mystery Boxes [Instruction booklet]. https://learning.sciencemuseumgroup.org.uk/wp-content/uploads/2020/04/SMG-Academy-Mystery-Boxes.pdf

Miller, D. K. G. (2014). *The effect of inquiry-based, hands-on labs on achievement in middle school science*. Doctorate Dissertation, Liberty University.

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction-what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching, 47*(4), 474–496.

Nagy, M. H. (1953). Children's conceptions of some bodily functions. *The Pedagogical Seminary and Journal of Genetic Psychology, 83*(2), 199-216.

National Research Council. (1996). National science education standards [Adobe Digital Editions version]. https://nap.nationalacademies.org/read/4962/chapter/1

National Research Council. (2000). Inquiry and the national science education standards [Adobe Digital Editions version]. https://nap.nationalacademies.org/read/9596/chapter/1

Newman, W., Abell, S. K., Hubbard, P. D., McDonald, J., Otaala, J., & Martini, M. (2004). Dilemmas of teaching inquiry in elementary science methods. *Journal of Science Teacher Education, 15*(4), 257–279.

Poderoso, C. (2013). *The science experience: The relationship between an inquiry-based science program and student outcomes*. Doctorate Dissertation, California State University.

Prokop, P., & Faněovičová, J. (2006). Students' ideas about the human body: do they really draw what they know?. *Journal of Baltic Science Education, 2*(10), 86–95.

Ramadas, J., & Nair, U. (1996). The system idea as a tool in understanding conceptions about the digestive system. *International Journal of Science Education, 18*(3), 355-368.

Reiss, M. J., & Tunnicliffe, S. D. (2001). Students' understandings of human organs and organ systems. *Research in Science Education, 31*(3), 383–399.

Rosenthal, J. L. (2018). Teacher candidates in the garden. *Science Activities, 55*(1), 20-27.

Stout, B. (2001). Tools for scientific inquiry in a fifth-grade classroom. *Primary Voices K – 6, 10*(1), 23-27.

Sullivan, F. R. (2008). Robotics and science literacy: Thinking skills, science process skills and systems understanding. *Journal of Research in Science Teaching, 45*(3), 373-394.

Tan, M. & Temiz, B. K. (2003). The importance and role of the science process skills in science teaching. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi, 13* (1), 89-101.

Teixeira, F. M. (2000). What happens to the food we eat? Children's conceptions of the structure and function of the digestive system. *International Journal of Science Education, 22*(5), 507-520.

van Riesen, S., Gijlers, H., Anjewierden, A., & de Jong, T. (2018). Supporting learners' experiment design. *Educational Technology Research and Development, 66*(2), 475– 491.

van Riesen, S. A., Gijlers, H., Anjewierden, A. A., & de Jong, T. (2022). The influence of prior knowledge on the effectiveness of guided experiment design. *Interactive Learning Environments, 30*(1), 17– 33.

van Uum, M. S. J., Verhoeff, R. P., & Peeters, M. (2016). Inquiry-based science education: Towards a pedagogical framework for primary school teachers. *International Journal of Science Education, 38*(3), 450–469.

Vosniadou, S. (2003). How children learn. Educational Practices Series-7. http://unesdoc.unesco.org/images/0012/001254/125456e.pdf%0A%0A

Witt, C., & Ulmer, J. (2014). The Impact of Inquiry-Based Learning on the Academic Achievement of Middle School Students. 2010 Western AAAE Research Conference Proceedings

Worth, K., Duque, M. ve Saltiel, E. (2009). Desinging and implementing inquiry-based science units for primary education. Pollen Project. www.pollen-europa.net

Wu, H-K., & Hsieh, C. E. (2006). Developing sixth grader's inquiry skills to construct explanations in inquiry-based learning environments. *International Journal of Science Education, 28*(11), 1289-1313.

Yerlikaya, A. & Güneş, M. H. (2017). Development and validation of the achievement test on body Systems . *Participatory Educational Research , Special Issue 2016-III ,* 68-76 . https://dergipark.org.tr/en/pub/per/issue/47525/600368

Zimmerman, C. (2007). The development of scientific thinking skills in elementary and middle school. *Developmental Review, 27*(2), 172–223.