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INVESTIGATION OF THE EFFECTS OF INQUIRY APPROACH ON SCIENCE ACHIEVEMENT IN DISTANCE EDUCATION

UZAKTAN EĞİTİMDE ARAŞTIRMA İNCELEME YAKLAŞIMININ FEN BAŞARISINA ETKİSİNİN İNCELENMESİ

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ÖZ: Dynamic structure of education and examination of hands-on activities in science education necessitates reforms that enable development and improvement in science programs. Distance education, which has gained importance during the pandemic period that has affected the whole world since the beginning of 2020, has also affected science education and the studies carried out in this period have gained importance in terms of examining student achievement. Investigation of the effects of inquiry approaches on science learning especially in the distance education can be considered as an important contribution to the literature. In this respect, this research aims to examine the effect of the guided inquiry approach on students' achievement and retention in the sixth-grade science course when the effects of reading comprehension skills are controlled. The sample of the study consists of 60 sixth graders from a public school. The students were assigned into two groups as experimental and control groups. In the experimental group, the guided inquiry approach was applied and in the control group, the traditional intructional method was used. The Systems in Our Body Achievement Test, which was developed as a data collection tool for the research, was applied to both groups as an immediate posttests and delayed posttests to determine the science achievement of the students. As a result, it was concluded that the inquiry approach applied in the distance education, where reading skills were statistically controlled, increased the success of the students in the science lesson compared to the traditional application.

Anahtar sözcükler: Guided inquiry approach, achievement, retention of learning, middle school science curriculum, COVID 19, distance education.

ABSTRACT: Fen eğitiminde uygulamalı etkinliklerin incelenmesi, eğitimin dinamik yapısı ile örtüşen fen programlarında gelişme ve iyileştirmeye olanak sağlayan reformları zorunlu kılmaktadır. 2020 yılının başından itibaren tüm dünyayı etkileyen pandemi sürecinde önem kazanan uzaktan eğitim, fen eğitimini de etkilemiş ve bu dönemde yapılan çalışmalar öğrenci başarılarının incelenmesi açısından önem kazanmıştır. Özellikle uzaktan eğitim sürecinde araştırma inceleme yaklaşımlarının fen öğrenimi üzerindeki etkilerinin araştırılması alanyazına önemli bir katkı olarak değerlendirilebilir. Bu doğrultuda araştırma, altıncı sınıf fen bilimleri dersinde yönlendirilmiş araştırma inceleme yaklaşımının okuduğunu anlama becerilerinin etkisi kontrol edildiğinde başarısıya ve kalıcılığa etkisini incelemeyi amaçlamaktadır. Araştırmanın örneklemini bir devlet okulunda öğrenim gören 60 altıncı sınıf öğrencisi oluşturmaktadır. Öğrenciler deney ve kontrol grubu olarak iki gruba ayrılmıştır. Deney grubunda yönlendirilmiş araştırma inceleme yaklaşımı, kontrol grubunda ise klasik öğretim yöntemi kullanılmıştır. Araştırmada veri toplama aracı olarak geliştirilen Vücudumuzdaki Sistemler Başarı Testi, öğrencilerin başarılarını belirlemek için her iki gruba son test ve geciktirilmiş son test olarak uygulanmıştır. Sonuç olarak okuma becerilerinin istatistiksel olarak kontrol edildiği uzaktan eğitim sürecinde uygulanan araştırma inceleme yaklaşımının öğrencilerin fen bilimleri dersindeki başarılarını klasik uygulamaya göre arttırdığı sonucuna ulaşılmıştır.

Keywords: Yönlendirilmiş araştırma inceleme yaklaşımı, başarı, kalıcılık, ortaokul fen programı, COVID 19, uzaktan eğitim

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TÜRKÇE GENİŞLETİLMİŞ ÖZET

Giriş

Fen öğretimi ve öğreniminin hem içeriği hem de pedagojisini incelemeye yönelik standartlar belirleyen Amerika Ulusal Fen Eğitimi Standartları (NSES), yapılandırmacılığın temele alındığı araştırma inceleme yönteminin bilimsel okuryazarlığın başarılmasında merkezi bir role sahip olduğunu ifade etmekle beraber tüm öğrencilerin hem bilimsel araştırmayı öğrenmelerini hem de araştırma inceleme yöntemiyle feni öğrenmelerini önermektedir (NRC, 1996). Fen eğitiminde reform için felsefi bir temel sağladığından öğrenmeye yönelik yapılandırmacı bir yaklaşımı destekleyen öğretim uygulamalarının önemli olduğu ifade edilmiştir (Bybee, 1993). Araştırma inceleme yöntemiyle öğretimde bilimsel yöntem kullanıldığından öğretmenlerin genellikle öğrencilere bir problem sunması sonrasında hipotezler oluşturmaları, durumla ilgili tahminlerde bulunarak deneyler yapmaları, veri toplayarak ve kaydederek hipotezlerini test etmeleri ve son olarak da veri analiziyle öğrencilerin sonuç çıkarmaları beklenmektedir (NRC, 1996). Sonuç olarak, araştırma inceleme yöntemiyle fen öğrenme, öğrencileri sorular sorarak, bilgi veya verileri toplayarak ve yorumlayarak, kanıta dayalı argümanlar ve sonuçlar oluşturarak problemleri keşfetmeye yönlendirmekte (Bransford, Brown & Cocking, 1999; Bell, Urhahne, Schanze & Ploetzner, 2010) bunun sonucu olarak ilköğretim düzeyinde bilimsel süreç becerilerini ve fen başarılarını artırdığı; ortaokul düzeyinde de bilimsel süreç becerilerini geliştirmelerine olanak sağladığı ifade edilmektedir (Shymansky, Hedges & Woodworth, 1990). İçerisinde bulunduğumuz pandemi süreci düşünüldüğünde, COVID 19 salgınıyla öne çıkan ve yaygınlaşan uzaktan eğitimin öğrenci başarısına etkilerini incelemek önem kazanmaktadır. Bu araştırma uzaktan eğitim sürecinde uygulanan araştırma inceleme yönteminin klasik uygulamaya göre öğrencilerin fen dersindeki alt düzey ve üst düzey düşünmeye yönelik başarılarını incelemeyi amaçlamaktadır. Amaç doğrultusunda bu araştırmanın alt düzey ve üst düzey düşünmeye yönelik fen başarısı ayrımını ortaya çıkarması ve yönlendirilmiş araştırma inceleme yaklaşımının fen öğrenimi üzerindeki etkisine yönelik uzaktan eğitimle yürütülen deneysel çalışmaların sınırlı olması bakımından alanyazına katkı sağlayacağı düşünülmektedir.

Yöntem

Bu çalışmada okuma becerilerinin istatistiksel olarak kontrol edildiği bir yapıda uzaktan eğitim sürecinde uygulanan araştırma inceleme yöntemin klasik uygulamaya göre öğrencilerin fen dersindeki alt ve üst düzey düşünmeye yönelik başarılarını arttırıp arttırmadığı incelenecektir. Amaç doğrultusunda araştırma deseni statik grup karşılaştırması olarak tanımlanmıştır. Bu desen iki grubun bir sonuç üzerine karşılaştırılmasına dayanır (Campbell & Stanley, 1963). Her iki grubu oluşturan öğrenciler rastgele atanmadığından grupların arka plan özelliklerinde farklılıklar gösterebileceği söylenebilir. Milli Eğitim Bakanlığı altıncı sınıf fen bilimleri öğretim programı incelendiğinde konulara göre dağılımın; %9.7 Dünya ve Evren, %29.2 Canlılar ve Yaşam, %33.3 Fiziksel Olaylar ve %19.4 Madde ve Doğası olduğu görülmektedir. Canlılar ve Yaşam konu alanı bir eğitim-öğretim döneminde tamamlanmasına ve konu dağılım oranına bağlı olarak belirlenmiştir. Her iki gruba ait ön test verilerinin mevcut olmadığı ilerleyen bölümlerde ifade edilmektedir. Ön test verilerinin olmayışı, fen öğretim programında öğrencilerin altıncı sınıfa kadar Vücudumuzdaki Sistemler ünitesiyle ilk kez karşılaşmaları nedeniyle ölçülemeyeceği şeklinde açıklanabilir. Grupların denkliğine yönelik kız ve erkek öğrencilerin oranları ile fen ders notları incelenmiş ve ilerleyen bölümlerde detaylandırılmıştır. Araştırma örneklemi, bir devlet okulunun altıncı sınıf iki şubesine kayıtlı toplam 60 öğrencidir. Deney grubunun %53'ünü (n=16) kız öğrenciler ve %47'sini (n=14) erkek öğrenciler; kontrol grubunun ise %47'sini (n=14) kız öğrenciler ve %53'ünü (n=16) erkek öğrenciler oluşturmaktadır. Gruplar Milli Eğitim Bakanlığı tarafından uygulama izni verilen şubelerde yürütülmüş, şubelere kayıtlı öğrencilerin sınıf düzenlerine müdahale edilememiş, sadece yönlendirilmiş araştırma yaklaşımının kullanılacağı deney grubu şubesi ile klasik yöntemin kullanılacağı kontrol şubesi tesadüfi olarak atanmıştır. Veri toplama aracı olarak, altıncı sınıf öğrencilerin alt düzey ve üst düzey düşünmeye yönelik fen başarılarını belirlemek amacıyla geliştirilen Vücudumuzdaki Sistemler Başarı Testi (VSBT) ünite sonunda ve öğretim sürecinin tamamlanmasından 6 hafta sonra her iki gruba uygulanmıştır. Marzano ve Kendall Taksonomisinde (2007), tekrar elde etme ve kavrama kategorileri alt düzey düşünme becerisi; analiz ve bilgiyi kullanma ise üst düzey düşünme

becerisi olarak tanımlanmıştır. Tekrar elde etme kategorisinde öğrencilerden bilgilere ilk sunulduğu gibi erişmeleri istenmekte, kavramada bilginin içselleştirilmesi amaçlanmakta, analizde yeni ilişkiler ve uygulamalar gerçekleştirilirken daha fazla bilginin öğrenilmesi hedeflenmekte ve son olarak bilgiyi kullanmada ise bilgiyi daha özgün görevlerde kullanılması beklenmektedir. Başarı testi, Milli Eğitim Bakanlığı Fen Bilimleri Dersi Öğretim Programının altıncı sınıflar için tanımladığı içerik tamamıyla temele alınarak Marzano ve Kendall taksonomisi alt düzey ve üst düzey düşünme becerileri merkezinde belirlenen hedeflere dönük 11 açık uçlu soru maddesinden oluşmaktadır. Kısa cevaplı olarak düzenlenen maddelerin 6 tanesi Marzano tarafından tanımlanan alt düzey beceri düzeylerine, 5 madde ise üst düzey düşünme becerilerini ölçmeye yöneliktir. Araştırmada belirlenen bağımlı değişkenlere ait alt ve üst puanların analizi tekrarlı ANCOVA Testi ile yapılmıştır. Araştırmada Alfa anlamlılık değeri .01 olarak kabul edilmiştir.

Bulgular

Tecrübelere dayalı bir fen öğretme-öğrenme yaklaşımının okuduğunu anlama becerilerinde oluşabilecek farklılıkların ortaya çıkmasını sağlayacağı (Esler & Anderson, 1981) gibi giriş davranışlarından biri olarak kabul edilen okuduğunu anlama becerilerinin istatistiksel olarak kontrol edilmesinin fen başarılarındaki farkların belirlenmesinde önemli bir ölçüt olabileceğidir. Analiz sonuçlarına göre, okuduğunu anlama becerilerinin kontrol edildiği deney grubu ile kontrol grubu öğrencilerinin alt düzey düşünme becerilerine yönelik başarı puanlarına göre .01 anlamlılık değerinde deney grubu öğrencileri lehine anlamlı bir fark olduğu sonucuna ulaşılmıştır. Okuduğunu anlama becerilerinin kontrol edildiği deney grubu ile kontrol grubu öğrencilerinin üst düzey düşünme becerilerine yönelik başarı puanlarına göre .01 anlamlılık değerinde deney grubu lehine manidar düzeyde bir fark olduğuna ulaşılmıştır.

Sonuç, Tartışma ve Öneriler

Bu araştırma, okuma becerilerinin istatistiksel olarak kontrol edildiği bir yapıda uzaktan eğitimle uygulanan araştırma inceleme yönteminin klasik uygulamaya göre öğrencilerin fen dersindeki alt düzey ve üst düzey düşünmeye yönelik başarılarını arttırdığı ve elde edilen bulguların literatürle benzerlik gösterdiği sonucuna ulaştırmaktadır (Saunders & Shepardson, 1987; Romance & Vitale, 1992; Germann, Aram & Burke, 1996; Köksal & Berberoğlu, 2012; Das, 2020). Araştırma inceleme yöntemiyle fen öğretiminde hangi yaklaşımın benimsenmesi gerektiği konusunda literatürde görüş ayrılıkları olmakla birlikte, bilimsel içeriğin doğrulanmasından açık araştırma inceleme yöntemine kadar farklı yaklaşımlarla yapılandırılabileceği belirtilmektedir (TaFoya, Sunal ve Knecht, 1980). Örneğin, Lunetta & Tamir (1979), doğrulayıcı araştırma inceleme yaklaşımında, öğrencilere nadiren üst düzey düşünme becerilerini kullanma fırsatının verildiğini, Sadeh & Zion (2009) ise yönlendirilmiş araştırma inceleme yaklaşımın fen içerik bilgisi ve bilimsel süreç becerilerinin kazandırılmasında daha etkili olduğunu ifade etmektedir. En genel ifadeyle, uzaktan eğitim sürecinde öğrencilerin fen bilimleri dersindeki akademik başarına ait bulguların geleneksel yüz yüze eğitimdeki fen başarı bulgularıyla benzerlik gösterdiğidir. Sonuç olarak, uzaktan eğitimle yürütülen yönlendirilmiş araştırma inceleme yaklaşımının alt düzey ve üst düzey düşünmeye yönelik fen başarısına manidar etkisinin olduğuna ulaşılmıştır. Araştırma bulgularına bağlı olarak diğer araştırma inceleme yaklaşımlarına yönelik uzaktan eğitimle yürütülen çalışmaların yapılması önerilebilir.

INTRODUCTION

The National Science Education Standards (NSES), set standards for examining both the content and pedagogy of science teaching and learning, argues that the inquiry method based on constructivism has a central role in the accomplishment of scientific literacy and suggest that all students should learn both scientific research and the use of the inquiry method to learn science (NRC, 1996). In this respect, the main objectives of the inquiry method are: (a) developing students' willingness and motivation to learn the principles and concepts of science, (b) developing students' science skills, and (c) introducing students to concept of being hardworking person/student (NRC, 2000). Considering that science represents more than a body of knowledge, the concepts of science directed to the understanding of the world should have knowledge-based explanations (Bybee, 1997). It is stated that attitudes and values related to science in the first years of school are important for the acquisition of scientific literacy, which includes students' ability to ask and answer questions about daily events on the basis of their curiosity, their ability to read and understand scientific texts and their ability to make decisions about scientific problems at the national and global level and that the inquiry-based science education will begin with the curiosity of children like scientists (NRC, 1996). In summary, given that inquiry skills of individuals in later stages of their lives are related to their experiences with science in the early stages of their lives (Bowman, 1998), science teaching will provide students with numerous opportunities to access existing knowledge, make sense of it (lower-order thinking skills) and create new knowledge (higher-order thinking skills) (Marzano & Kendall, 2007).

Methods used to teach science are classified as teacher-centered and student-centered. In teacher-centered teaching, it is stated that assigning meanings should be done by the teacher and these meanings should be communicated to students through the coursework, textbooks and supplementary activities determined by the teacher, while the purpose of the teaching is to help students know only scientific explanations. In student-centered teaching, students are allowed and even encouraged to make their own sense while the teacher acts as a guide to support the learning of students who are engaged in scientific activities (Duschl, Schweingruber & Shouse, 2007). It can be stated that student-centered learning is presented as an alternative to teacher-centered teaching, that it provides activities that give students the opportunity to test theories and explore problems critically (Dewey, 1938) and it is emphasized that it is a social process that develops through interaction with the environment (Vygotsky, 1978). Vygotsky sky defines the area between the student's current level of development determined by independent problem solving and the level of development that can be achieved under adult guidance as the Zone of Proximal Development and states that when a student is on the verge of responding to a problem he/she encounters in the development process, he/she can overcome this problem with the help of a mentor and he/she will improve his/her learning and comprehension by reaching a new level of learning through active participation in learning. In order for students to participate actively in learning, they need to be engaged in higher-order thinking activities such as using and analyzing information. Many different strategies such as experiential learning, cooperative learning, problem solving and classroom discussions can be used to involve students in these activities (Keyser, 2000).

It can be said that student-centered education was born with the constructivist development theory (Kolb, 1984; DeVries & Kohlberg, 1994) and the progressive education movement of the early 20th century (Dewey, 1938). It is noted that the term "invention" has been associated with teaching and learning among cognitive psychologists and educators since the 1960s, and has become known under various names such as invention, research and inquiry, applied activities, constructivist approach used to enhance the role of students in acquiring new knowledge (Shulman & Keislar, 1966). Inquiry-based learning is defined as a general teaching approach that represents the first broad development of constructivism for learning environments and contributes to involving students in cognitively guided activities. Scientific inquiry, defined as the methods used by scientists, includes processes such as observation and experimentation. In the version that results in empirical evidence and is used in teacher-centered settings, students are often involved in laboratory activities that consist of a series of steps. This ensures that the use of laboratory activities in science teaching only validates the material presented in textbooks (Bybee et all., 1991). However, learning science involves making connections and helping students relate their new knowledge to their previous experiences (Cox-Peterson & Olson, 2002). In this regard, children's science learning can be better characterized by changes in their thinking (Shapiro, 1994); that is, as they are exposed to new information, they can review and reorganize their old

knowledge and deepen their understanding (Carey, 1986). In this respect, the application of inquiry-based learning methods can contribute to the acquisition of higher-order thinking skills, which is an important goal of education.

Since constructivism provides a philosophical basis for reform in science education (NRC, 1996) it is stated that the transition to teaching practices that support a constructivist approach to learning is important (Bybee, 1993). Teaching science as an inquiry process requires involving students in inquiry-based learning environments, while learning science as an inquiry process involves students using scientific process skills to explore and understand the world (Rakow, 1986). Since the scientific method is used in teaching with the inquiry method, students are expected to formulate hypotheses after the teacher has presented a problem, to conduct experiments by making predictions about the given situation, to test their hypotheses by collecting and recording data and finally to draw conclusions through data analysis (NRC, 1996). As a result, learning science through the inquiry method leads students to the exploration of problems by asking questions, collecting and interpreting information or data, creating evidence-based arguments and conclusions (Bransford, Brown & Cocking, 1999; Bell, Urhahne, Schanze & Ploetzner, 2010) and thus it contributes to the development of science process skills and to science achievement at primary and secondary school level (Shymansky, Hedges & Woodworth, 1990).

It can be stated that statistical control of reading comprehension skills, which is accepted as one of the cognitive entry behaviors, can be an important criterion in determining the differences in science achievement. This situation can be supported by the necessity of developing students' reading comprehension skills in science programs (NRC, 1996). While the fact that reading comprehension skills are necessary to understand science texts (Kinniburgh & Shaw, 2009), students' communication and reading comprehension skills are both important factors for their success in science programs/science achievement (Schiefele, Schaffner, Möller & Wigfield, 2012). In this regard, research focuses on the integration of reading and science teaching while expressing that there is an interaction between student's success in science and his/her reading skills (Romance & Vitale 1992; Flick 1995; Morrow, Pressley, Smith & Smith 1997). The study of Romance and Vitale can be given as an example (Romance & Vitale, 1992). In the study, the effect of a program that integrates reading with applied science activities and scientific process skills on science, mathematics and reading skills was examined. On the basis of the reading scores, it was concluded that the science achievement of the students in the experimental group was significantly higher than that of the students in the control group.

In the literature, significant effects of the inquiry method have been reported on science achievement in classrooms where the inquiry method has been applied (Shymansky, Kyle & Alport, 1983). It is stated that inquiry-oriented science programs in secondary school classes increase success especially in terms of laboratory skills, graphics and data interpretation skills (Mattheis ve Nakayama, 1988), and similarly, many studies have revealed that the use of inquiry approaches have a positive effect on success and retention (Saunders & Shepardson, 1987; Germann, Aram & Burke, 1996; Köksal & Berberoğlu, 2012; Das, 2020). For example, in the study conducted by Köksal and Berberoğlu, it was found that the inquiry approach directed to the unit "Reproduction, Growth and Development in Living Things" in the sixth-grade science curriculum resulted in a significant increase in science achievement compared to the traditional method and that decreases occurred in the retention scores of both groups (Köksal & Berberoğlu, 2012). In another study conducted by Das to investigate the effect of the inquiry method on the science achievement of secondary school seventh grade students and it was found that the inquiry method brought about a significant difference compared to the traditional method (Das, 2020). Finally, Bogar, Kalender, and Sarıkaya aimed to examine the effect of constructivist strategies on the science achievement and retention of students and they concluded that there was a significant difference in favor of the experimental group in terms of science achievement and the students in the experimental group had higher retention scores (Bogar, Kalender & Sarıkaya, 2012). As a result, it can be claimed that applied activities have a positive effect on student achievement in terms of providing opportunities for students to participate in scientific research and inquiry processes in traditional face-to-face education. Considering the pandemic period we are in, it is important to examine the effects of distance education, on student success. Historically, distance education, education system of adult students living in places where the traditional education system cannot reach used to allow it to enter (Hawkins, 1999). Distance education, which dates back to the 1700s as a concept and started with letter teaching practices, continued its development in parallel with the advances in technology. Finally, it has

gained its current meaning and importance with information technologies. The current study aims to examine students' achievements in lower-order and higher-order thinking in science lessons instructed through the guided inquiry method and the traditional method. Thus, the current study is thought to make important contributions to the literature by revealing the difference between the lower-order and higher-order thinking skills of the groups instructed through different methods and the effect of the guided inquiry approach on science teaching. The research problem of the study is presented below.

1. Are the lower and higher order thinking skills, when the reading comprehension processes are controlled of the sixth-grade students who instructed by means of the inquiry method, significantly different than from those of the sixth graders who instructed by means of the traditional method during the distance education according to the results of students' science achievement and learning?

(a) Are the lower-order thinking skills (when the reading comprehension processes are controlled) of the sixth-grade students instructed by means of the inquiry method significantly different from those of the sixth graders instructed by means of the traditional method during the distance education process according to the results of the immediate posttest and delayed posttest?

(b) Are the higher-order thinking skills (when the reading comprehension processes are controlled) of the sixth-grade students instructed by means of the inquiry method significantly different from those of the sixth graders instructed by means of the traditional method during the distance education process according to the results of the immediate posttest and delayed posttest?

METHODS

Research Design

In the current study, it was aimed to investigate whether the inquiry method applied in a structure where the comprehension skills were statistically controlled performed significantly better than the traditional method in terms of improving students' success in lower and higher-order thinking in science classes during the distance education process. For this purpose, the research design was defined as static group comparison. This design is based on comparing two groups on an outcome (Campbell ve Stanley, 1963). Since the students forming both groups were not randomly assigned, it can be said that the background characteristics of the groups may differ. It is stated in the following sections that pretest data for both groups are not available. The reason for the absence of pretest data can be explained by the fact that the students cannot be measured until the sixth-grade because they encounter the study unit "Systems in Our Body" for the first time in the sixth grade. For the equivalence of the groups, the ratios of male and female students and their course grades were examined and detailed in the following sections.

Sample of the Study

The sample comprised of a total of 60 students enrolled in two sixth-grade classes from a public school in Turkey. Of the experimental group students, 53% (n=16) are females and 47% (n=14) are males, while 47% (n=14) of the control group students are females and 53% (n=16) are males. The study was carried out in the classes approved by the Ministry of National Education, no intervention was made in the arrangements of the students in the classes and the students were randomly assigned to the experimental group where the guided inquiry method would be applied and the control group where the traditional method would be applied.

Data Collection Instruments

As the data collection instrument, the Systems in Our Body Achievement Test (VSBT), which was developed to determine the science achievement of sixth grade students for lower-order and higher-order thinking, was administered to both groups at the end of the unit to measure achievement level of the students. Six weeks after the completion of the teaching process the same instrument was administrated to the students as delayed posttest to measure their retention level in Marzano and Kendall Taxonomy (2007), retrieval and comprehension categories are lower-order thinking skills while analysis and using information are defined as higher-order thinking skills. The achievement test consists of 11

open-ended questions constructed on the basis of the content defined by the Ministry of National Education for the science curriculum of sixth graders and the lower-order and higher-order thinking skills in Marzano and Kendall Taxonomy. Of the questions organized to be short answer questions, 6 were designed to measure lower-order thinking skills while 5 of them were designed to measure higher-order thinking skills. The reliability coefficient calculated with the scoring reliability of the test for each question was found to be .92. In the determination of the validity of the test, the Content Validity Index (CVI) value for each item and the general scale was calculated by taking the opinion of 3 experts. The experts were either academicians in science education or teachers who completed their doctoral studies. The experts were asked to rate each item of the test developed for the Unit of Systems in Our Body according to their level of relevance to the specifications in the curriculum. The rating was performed on a 4-point rating rubric; not relevant (1), somewhat relevant (2), relevant (3) and highly relevant (4) (Davis, 1992). Afterwards, the item content validity index was calculated by dividing the number of experts who rated each item as relevant and highly relevant to the total number of experts. As a result, the S-CVI / Ave value was found to be .91 and sufficient, with three experts agreeing on 10 questions (CGI=1.00) and disagreeing on one question (CGI=0.67) (Polit, Beck & Owen, 2007).

Reading comprehension skills, which were used as covariate in the study, were measured with the Reading Comprehension Test. The test was prepared using four different reading texts, each consisting of 11 items. The Reading Comprehension Test was administered in four sessions, in each of which a text was addressed per week, during the interaction process that lasted for 5 weeks. The reliability coefficients cal-culated with the scoring reliability of the subtests for each question were found to be .80, .82, .96 and .86, respectively. In the scale prepared to determine the validity of the test, the Content Validity Index (CVI) value for each item and the general scale was calculated by taking the opinion of 3 experts. The experts were the teachers who were at the doctoral thesis stage in science education and teachers who were experts on teaching Turkish. In order to calculate the content validity at the item level for the developed reading text items, the experts were asked to rate the relevance level of each item. The rating was performed on a 4-point rating rubric; not relevant (1), somewhat relevant (2), relevant (3) and highly relevant (4) (Davis, 1992). Then, for each item, the item content validity index was calculated by dividing the number of experts rating the item as relevant and highly relevant by the total number of experts. As a result, it was concluded that the three experts agreed on 44 questions (CGI=1.00).

Data Analysis

The analysis of the lower and upper scores of the dependent variables (students' science achievement and learning) determined in the study was performed with the repeated ANCOVA Test.

Procedures

The two different teaching methods described refer to the inquiry method for the experimental group students and the traditional method for the control group students. The teaching period for both of the groups lasted for 5 weeks. Due to the developing pandemic conditions, since the first semester of the 2019-2020 school year, education in schools at all levels has been conducted through distance education and the instruction in the current study has been delivered via distance education. The classes delivered through distance education were carried out on the Education Information Network (EBA) of the Ministry of National Education. In the guided inquiry approach used in the current study, the teacher only provides the problem to be investigated by the students, and the students create their methods and results to solve the problem. The teacher acts as a guide for students to decide how best to answer the problem and to continue their inquiry. The teacher of the group in which the experimental procedure would be applied was given information on how to apply the guided inquiry approach and he/she was also given the teacher plans and student activity plans before the application. The control group, in which the traditional method would be applied, was given information about the test applications. For the cognitive domain, in the Taxonomy of Marzano and Kendall (2007), the categories of retrieval and comprehension are defined as lower-order thinking skills while the categories of analysis and using information are defined as higher-order thinking skills. Accordingly, on the basis of the content defined by the Ministry of National Education Science curriculum for sixth graders and the lower-order and

higher-order thinking skills defined in Marzano and Kendall taxonomy, objectives were defined. Two of the inquiry activities developed by the researcher and applied in the experimental group are given below as examples.

Table 1.

Activities	Descriptions
First activitiy	Objective 1. Analyzes the similarities and differences between the skeletal structures of different living things and the human. Activity 1. Let's examine the chicken and fish skeleton structures (classroom activity) Students were expected to form hypotheses about the similarities and differences of the skeletal structures of chicken and fish, such as "the shapes of the bones forming the chicken skeleton are similar to those of the fish skeleton" and the following stages were defined in the classroom activities within the framework of the guided inquiry approach: • answering questions that measure their prior knowledge of the subject, • researching questions on the subject, • determining hypotheses for the research question, • planning the experiment for the determined hypothesis, • deciding whether to accept or reject the hypothesis depending on the result of the experiment, • explaining the judgment reached on the basis of the result of the experiment.
Second activity	Objective 1. Analyzes the similarities and differences between the skeletal structures of different living things and the human. Activity 2. Let's examine bones in different liquids (homework activity) Students were expected to form hypotheses about the level of hardness of bones kept in different liquids, such as "as the pH level of the liquid decreases, bone hardness decreases" and the following stages were defined in the homework activities within the framework of the guided inquiry approach: • answering questions that measure their prior knowledge of the subject, • researching questions on the subject, • determining hypotheses for the research question, • planning the experiment for the determined hypothesis, • deciding whether to accept or reject the hypothesis depending on the result of the experiment, • explaining the judgment reached on the basis of the result of the experiment, • relating the subject to nature-technology-society.

Examples of activities applied in the experimental group

In order to prevent the problems that could be caused by the distance education process, the researcher provided the students with scientific tools, materials and equipment to be used in the activities to be conducted in the experimental group before the implementation of the activities in case they might not find them in their home environments. After the completion of the teaching process, VSBT was applied to both groups in order to determine the science achievements of the experimental and control groups for lower-order and higher-order thinking skills online and simultaneously, then 6 weeks after the end of the application, VSBT was used as a delayed posttest. The Reading Comprehension Test used to measure the reading comprehension skills, which were defined as covariate in the current study as reading is a cognitive entry behavior for all school subjects, was administered as four subtests depending on the session duration in order to determine the development of the students in the process.

Ethical Consent of the Research

The ethics committee permission of Hacettepe University Ethics Committee dated 25.03.2020 and numbered 51944218-300/00001064047 was obtained for this research.

FINDINGS

In this section, it has been examined whether the inquiry method applied in the distance education within a framework where reading skills are statistically controlled increases the success of students in lower-order and higher-order thinking in science classes more than the traditional method and the results obtained are presented in order specified by the sub-problems of the study. An independent samples t-test was conducted to compare the science course grades of the students in order to prove the equivalence of the experimental and control groups and the results of the analysis are presented below.

Table 2.
Independent samples t-test results for the course grades of the experimental and control groups

Variable	N	Mean	sd	t	df	p
Experimental group	30	76.00	11.700	-1.677	58	.099
Control group	30	80.83	10.593			

When Table 2 is examined, it is seen that there is no significant difference between the experimental and control group students in terms of their course grades. This finding reveals that the experimental and control groups was equivalent.

In the study, an answer was sought to 'How do the experimental (guided inquiry instruction) group students' immediate posttest and delayed posttest scores differ from that of students in the control (traditional instruction) group?'. First, the assumptions of ANCOVA analysis were examined, and after the rejection of the null hypothesis for homogeneity of within-group regression slopes, it was determined that the rXY > 0.3 condition was met between success and retention and reading comprehension processes (Frigon & Laurencelle, 1993). In order to find an answer to the determined sub-problem, lower-order thinking skills scores were analyzed with the repeated ANCOVA test. While Table 3 presents descriptive statistics for the lower-order thinking scores, Table 4 presents the results of the analysis of the scores.

Table 3.
Means and standard deviation scores for the lower-order thinking skills scores

Group/Test scores	Immediate posttest mean score for the lower-order thinking skills $\bar{X}$ lower-order thinking		Delayed posttest mean score for the lower-order thinking skills $\bar{X}$ lower-order thinking	
	$\bar{X}$	sd	$\bar{X}$	sd
Experimental group	9.00	1.287	8.77	1.675
Control group	5.43	3.277	3.67	2.670

As can be seen in Table 3, while the immediate posttest mean score for lower-order thinking skills of the experimental group students instructed by means of the guided inquiry instruction was found to be $\bar{X}$=9.00, it was found to be $\bar{X}$=5.43 for the control group students instructed by means of the traditional instruction. On the other hand, while the delayed posttest mean score for lower-order thinking skills of the experimental group students was found to be $\bar{X}$=8.77, it was found to be $\bar{X}$=3.67 for the control group students.

Table 4.
Repeated ANCOVA results for the lower-order thinking skills scores

Variable	Sum of Squares	df	Mean Square	F	p	Eta square
Between-groups	365.435	58				
Group	119.801	1	119.801	27.800	.000	.328
Error	245.634	57	4.309			

According to the results of the analysis, it was concluded that there was a significant difference between the immediate posttest mean scores of the experimental and control groups for the lower-order thinking skills in favor of the experimental group students ($p<.01$) when their reading comprehension processes were controlled. To put it more clearly, when the reading comprehension processes were controlled, the lower-order thinking skills of the sixth-grade science students who received distance education through the inquiry instruction were found to be significantly higher than those of the control group students according to the immediate posttest and delayed posttest scores.

Finally, in order to find an answer to the determined sub-problem, higher-order thinking skills scores were analyzed with the repeated ANCOVA test. The findings obtained from the analysis are presented in Table 5 and Table 6.

Table 5.
Means and standard deviation scores for the higher-order thinking skills scores

Group/Test scores	Immediate posttest mean score for the higher-order thinking skills $\bar{X}$ higher-order thinking		Delayed posttest mean score for the higher-order thinking skills $\bar{X}$ higher-order thinking	
	$\bar{X}$	sd	$\bar{X}$	sd
Experimental group	7.20	1.669	6.93	1.929
Control group	4.67	2.771	3.27	2.033

As can be seen in Table 4, while the immediate posttest mean score for the higher-order thinking skills of the experimental group students instructed by means of the guided inquiry instruction was found to be $\bar{X}=7.20$, it was found to be $\bar{X}=4.67$ for the control group students instructed by means of the traditional instruction. On the other hand, while the delayed posttest mean score for lower-order thinking skills of the experimental group students was found to be $\bar{X}=6.93$, it was found to be $\bar{X}=3.27$ for the control group students.

Table 6.
Repeated ANCOVA results for the higher-order thinking skills scores

Variable	Sum of Squares	df	Mean Square	F	p	Eta square
Between-groups	281.135	58				
Group	45.107	1	45.107	10.893	.002	.160
Error	236.028	57	4.141			

According to the results of the analysis, it was concluded that there was a significant difference between the immediate posttest mean scores of the experimental and control groups for the higher-order thinking skills in favor of the experimental group students ($p<.01$) when their reading comprehension processes were controlled. In other words, when the reading comprehension processes were controlled, the higher-order thinking skills of the sixth-grade science students who received distance education

through the inquiry instruction were found to be significantly higher than those of the control group students according to the immediate posttest and delayed posttest scores.

DISCUSSION, CONCLUSION and SUGGESTIONS

In the current study, it was concluded that the inquiry instruction method applied through distance education in a structure in which reading skills were statistically controlled increased the success of students in lower-order and higher-order thinking in science classes more than the traditional instruction method and this finding concurs with the literature (Saunders & Shepardson, 1987; Romance & Vitale, 1992; Germann, Aram & Burke, 1996; Köksal & Berberoğlu, 2012; Das, 2020). For example, Shymansky, Kyle, and Alport found that the inquiry instruction method significantly affected students' achievement in lower-order and higher-order thinking compared to the traditional instruction method and when these effects were analyzed across the subject areas, it was found that while the use of the inquiry instruction method in biology and physics teaching positively affected the students' achievement in lower-order and higher-order thinking, it did not show similar effects in astronomy and chemistry teaching (Shymansky, Kyle & Alport, 1983). As the subject addressed in the current study is related to biology, the findings of these two studies can be said to be similar and it can be suggested to conduct research on other subject areas. As the research findings support science learning through the inquiry instruction method, it can be said that distance education environments in which the inquiry instruction method is used will be effective in the development of lower and higher order thinking skills. Laboratory activities carried out in secondary school science classes are said to generally focus on content knowledge rather than developing students' inquiry skills (Abrahams & Millar, 2008; Titrek & Cobern, 2011). However, a instruction method that does not support students in drawing conclusions based on the data obtained from the experiments is unlikely to achieve the goal of science literacy. Although there are differences of opinion in the literature about which approach should be adopted in science teaching with the inquiry instruction method, it is stated that it can be structured with different methods, from validation of scientific content to open inquiry instruction method (TaFoya, Sunal & Knecht, 1980). Millar (1991) states that students in open inquiry instruction method labs may be more likely to develop scientific thinking skills than students in confirmation inquiry instruction method labs, and consistent with this finding, Lunetta & Tamir (1979) state that in the confirmation inquiry instruction method, students are rarely given the opportunity to discuss important scientific knowledge about using higher-order thinking skills. Sadeh & Zion (2009) argue that the guided approach is more effective in gaining science content knowledge and scientific process skills. Berberoğlu, Çelebi, Özdemir, Uysal & Yayan (2003) found that student-centered classroom activities, which are thought to affect students' science achievement, negatively affect student achievement, and more specifically, the TIMSS science and mathematics scores of students who stated that the course was conducted as group work or project-based intruction decreased. As a result, it can be argued that students who learn science with applied methods out perform students who learn science with traditional instruction methods (Shymansky, Kyle & Alport, 1983). It seems that the findings on student achievement in distance education are similar to the findings on student achievement in traditional face-to-face education. As it was found that the inquiry instruction method implemented in a distance education environment significantly increased science achievement in lower-order and higher-order thinking skills, further research can investigate the effect of the inquiry method in other subject areas.

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