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The Effect of Predict-Observe-Explain Strategy on Students' Academic Achievement, Scientific Process Skills and Attitude towards Science *

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Abstract

Purpose: When the science lesson curriculum is examined, it is seen that the main purpose is to raise science literate individuals. In order to achieve this goal, constructivist approaches are needed instead of traditional teaching approaches. Predict Observe Explain (POE) is also one of the tools suitable for constructivism and includes a demonstration experiment and related prediction and observation steps. This study aims to investigate the effects of the Predict-Observe-Explain (POE) strategy on fourth grade students' academic achievement, scientific process skills, and attitude towards science

Design & Methodology: In this semi-experimental research design, 17 students were in the control group and 15 were in the experimental group. For data collection, three different scales were used. The scales were administered to all participants at the beginning and at the end of the implementation. The experimental group was exposed to POE during their lessons for six weeks and the control group received regular instruction which is suggested by the Ministry of National Education.

Findings: The results revealed that students in the experimental group had significantly higher scores than the students in the control group in terms of academic achievement and scientific process skills. However, no difference was observed in their attitude towards science.

Implications & Suggestions: In subsequent studies, the effects of POE on different age groups can be analyzed.

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Tahmin Et-Gözle-Açıkla Stratejisinin Öğrencilerin Akademik Başarıları, Bilimsel Süreç Becerileri ve Bilime Yönelik Tutumları Üzerindeki Etkileri *

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Öz

Amaç: Fen bilimleri dersi öğretim programı incelendiğinde temel amacının fen okuryazarı bireyler yetiştirmek olduğu görülmektedir. Bu amaca ulaşmak için geleneksel öğretim yaklaşımları yerine yapılandırmacılığa uygun yaklaşımlara ihtiyaç duyulmaktadır. Tahmin Et Gözle Açıkla (TGA) da yapılandırmacılığa uygun araçlardan biri olup bir gösteri deneyi ve buna bağlı tahmin ve gözlem basamaklarını içermektedir. Bu çalışma Tahmin Et Gözle Açıkla (TGA) stratejisinin ilkokul dördüncü sınıf öğrencilerinin akademik başarıları, bilimsel süreç becerileri ve fene karşı tutumlarına olan etkisini araştırmayı amaçlamaktadır.

Yöntem: Bu yarı deneysel araştırma deseninde 17 öğrenci kontrol grubunda ve 15 öğrenci deney grubundadır. Veri toplama için üç farklı ölçek kullanılmıştır. Ölçekler, uygulamanın başında ve sonunda tüm katılımcılara uygulanmıştır. Deney grubunda altı hafta boyunca dersler TGA'ya göre işlenmiş ve kontrol grubuna ise Milli Eğitim Bakanlığı'nın önerdiği şekilde eğitim verilmiştir.

Bulgular: Sonuçlar deney grubundaki öğrencilerin akademik başarı ve bilimsel süreç becerileri açısından kontrol grubundaki öğrencilere göre anlamlı düzeyde daha yüksek puanlara sahip olduğunu ortaya koymuştur. Ancak bilime karşı tutumlarında bir farklılık gözlenmemiştir.

Sonuçlar ve Öneriler: Sonraki çalışmalarda, TGA'nın farklı yaş grupları üzerindeki etkileri analiz edilebilir.

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INTRODUCTION

In education, different educational approaches have been adopted to achieve the educational goals (Hançer, 2009; Kalaycı, 2014). Instead of teacher-centered traditional approaches, the constructivist approach, in which learners construct knowledge through their own decisions, has been adopted especially in science education (Turgut, 2002; Ünal & Çelikkaya, 2009; Arslan, 2016). In other words, societies reorganized their educational programs by implementing the constructivist approach (İnci, 2015) in order to adapt to the changes in science and technology. In this respect, great importance has been given to various models for the implementation of the constructivist learning approach in recent years (Karatekin, 2012; Göktürk, 2015; Harman, 2015).

Predict-Observe-Explain (POE) strategy is one of the methods suitable for constructivist approach and aims to identify and eliminate students' misconceptions and increase the comprehension level of them (Tekin, 2008; Rini, Suryani & Fadhilah, 2019). In accordance with the nature of the constructivist approach, POE enables students to actively involve in their own learning processes (Köseoğlu, Tümay & Kavak, 2002; Tekin, 2008) and requires students to make predictions before an experiment, observe, and, finally, explain what happened in the experiment based on their observations (Kearney & Treagust, 2001; Atasoy, 2004). This enables students to take their own responsibilities and uncover their misconceptions and contradictions (Mısır, 2009; Tokur, 2011). This misconceptions and contradictions that occur during the implementation of POE contribute greatly to the formation of meaningful learning (Kırılmazkaya & Kırbağ-Zengin, 2015; Sağıekmekçi, 2016). Using the previous knowledge and experiences to explain the new situations, measuring individuals' competence during the application, and revealing misconceptions are considered as the advantages of POE (Tokur, 2011; Nurhuda, Lukito & Djalil, 2018).

The Aim and Significance of Study

When the researches are examined, it shows that the use of methods and techniques based on constructivism provides a great benefit to individuals in terms of the permanence of the information and the elimination of misconceptions (Kearney &Treagust, 2001; Bilen, 2009). At the same time, it is emphasized that the students do not make any effort to change the misconceptions and only the activities suggested by the Ministry of National Education' Science Programme may be insufficient sometimes (Arslan, 2013). In this changing world, through POE or similar methods there is a need for students to find scientific truths based on their grade level and to ensure persistency in learning (Kara, 2017; Özçelik, 2019). However, it was observed that there are limited studies on primary school 3rd and 4th grade science courses on the POE.

Therefore, this study aims to investigate the effect of POE on fourth grade students' academic achievement, scientific process skills, and attitudes towards science and the following research questions were proposed:

1. Is there any statistically significant difference between the experimental and the control groups pre-test scores in terms of following variables:
    a. Academic achievement
    b. Scientific process skills
    c. Attitudes towards science
2. Is there any statistically significant difference between the experimental and the control groups post-test scores in terms of following variables:

   a. Academic achievement
   b. Scientific process skills
   c. Attitudes towards science
3. Is there any statistically significant difference between the pre- and post-test scores of the control group in terms of following variables:
   a. Academic achievement
   b. Scientific process skills
   c. Attitudes towards science
4. Is there any statistically significant difference between the pre- and post-test scores of the experimental group in terms of following variables:
   a. Academic achievement
   b. Scientific process skills
   c. Attitudes towards science

METHOD

Research Model

In order to examine the effects of POE on students' academic achievement, scientific process skills, and attitudes towards science, a semi-experimental research was designed (Karasar, 2002; Çepni, 2011). Semi-experimental research is employed in situations in which the true experimental design models' criteria are not met (Çepni, 2011). In this study, while participants in the experimental and the control groups were administered the pre-and post-tests, only the participants in the experimental group were exposed to POE, as Creswell (2003) suggested.

Participants

The study included a total of 32 fourth grade students enrolled in a school located in the eastern part of Turkey. While 17 students in the same classroom were assigned as the control group, the remaining in the same classroom was assigned as the experimental group. The experimental group was exposed to POE in their science lessons.

Data Collection Process

Before the study, the researchers met the school administrator, the teachers, and the participants and introduced the study to them. After getting consents from the teachers and students' parents, the groups were identified by random assignment. The implementation took six weeks between 5 December 2016-17 February 2017. The topic was the properties of matter. Each group was administered pre-tests at the beginning of the implementation and post-tests at the end of it. While the experimental group was taught the topic by using POE worksheets, the control group was received the instruction based on the fourth grade science curriculum with regular teaching methods. Before the application, students were given information about POE and in-class practices focused on. Notes on the problems that occurred during the sample applications were taken and feedbacks were given to the students. Lessons in the experimental and control groups were conducted by the same teacher.

Data Collection Tools

In order to seek answers to the research questions, three different data collection tools were chosen. The first tool was an academic achievement test. The researchers developed a 30-item test in order to determine students' academic achievement levels. The questions were related to the properties of matter and all of them were multiple choice questions. Before the administration, the item difficulty and item discrimination indices were calculated and expert views were obtained. Item discrimination strength index values were calculated as .20 and above. After the items between .20 and .29 were corrected, they were included in the academic achievement test. Based on the results (Karaçallı, 2011) and expert views, no modification was done on questions in the test. The second tool was the scientific process skills test developed by Padilla, Cronin and Twiest (1985) and translated into Turkish by Aydoğdu and Karakuş (2015). It includes six factors: observation (5 items), categorization (5 items), inference (5 items), measurement (5 items) estimation (6 items), and communication (5 items). While the reliability of the scale (KR-20) was calculated as .83, the average difficulty level of the scale was calculated as .55. The last data collection tool was related to students' attitudes towards science. In the study, a scale developed by Geban and colleagues (1994) was used. The scale consists of 15 items with reliability coefficient value of .83. It is a five-point Likert type ranging from strongly disagree to strongly agree.

Data Analysis

In order to conduct analysis, IBM SPSS version 21 was used. Before the analysis, the data was screened to determine whether it was normally distributed. The Shapiro-Wilk test was performed and kurtosis and skewness values were calculated. The results revealed that the data was normally distributed. In order to compare the test scores of the groups, an independent samples t test and a paired sample t test were performed. The p value was accepted as being meaningful if $p < .05$.

FINDINGS

Findings Regarding The Pre-test Scores

An independent samples t test was performed in order to compare the experimental group with the control group in terms of their pre-test scores. According to the results, no significant difference was observed. The results are provided in Table 1.

Table 1

Independent Samples t- Test Results In Term Of The Pre-Test Scores

Groups	N	X̄	Sd	t	p	ή2
		Academic achievement				
Control group	17	9.76	4.80	.706	.485	.01
Experimental group	15	10.8	3,21			
		Scientific process skills				
Control group	17	14.17	3.60	1.907	.066	0.1
Experimental group	15	17.06	4,93			
		Attitudes towards science				
Control group	17	63	6.52	.958	.346	.02
Experimental group	15	61	5.07			

Findings Regarding The Post-test Scores

The post-test scores of the experimental group and the control group were compared by using an independent samples t test. The results revealed significant increases in academic achievement scores and the scientific process skills in favor of the experimental group. The results are provided in Table 2.

Table 2
Independent samples t- test results in terms of the post-test scores

Groups	N	x̄	Sd	t	p	ή2
			Academic achievement			
Control group	17	16.88	3.07	3.66	.001*	.3
Experimental group	15	22.60	5.55			
			Scientific process skills			
Control group	17	14.76	4.43	2.492	.018*	.17
Experimental group	15	18.40	3.71			
			Attitudes towards science			
Control group	17	63	6.52	.958	.346	.02
Experimental group	15	61	5,07			

* p < .05

Findings Regarding The Scores of The Control Group

In order to determine any changes in the pre- and post-test scores of the control group, a paired samples t test was performed. Only significant difference was observed in their academic achievement scores. Their academic achievement scores significantly increased from 9.76 to 16.88 (p < .000). The results are given in Table 3.

Table 3
Paired samples t test results for the control group

Groups	N	x̄	Sd	t	p	ή2
			Academic achievement			
Pre-test	17	9.76	4.80	5.451	.000*	.49
Post-test	17	16.88	3.07			
			Scientific process skills			
Pre-test	17	14.17	3.60	.457	.654	.006
Post-test	17	14,76	4.43			
			Attitudes towards science			
Pre-test	17	63.00	6.52	.114	.910	.000
Post-test	17	62.76	3.23			

* p < .05

Findings Regarding The Scores of The Experimental Group

In order to determine any changes in the pre- and post-test scores of the experimental group, a paired samples t test was performed. According to the results, although increases were observed for three scores, only the increase in academic achievement score was significant. The results are provided in Table 4.

Table 4

Paired samples t test results for the experimental group

Groups	N	x̄	Sd	t	p	ή2
			Academic achievement			
Pre-test	15	10.80	3.21	9.465	.000*	.69
Post-test	15	22.60	5.55			
			Basic process skills			
Pre-test	15	17.06	4.93	.739	.472	.01*
Post-test	15	18.40	3.71			
			Attitudes towards science			
Pre-test	15	61.00	5.07	1.974	.068	.11
Post-test	15	63.33	3.22			

* p < .05

DISCUSSION AND CONCLUSION

This study aims to investigate the effects of POE on fourth grade students' academic achievement, scientific process skills, and attitudes towards science. The first critical finding of the study is related to students' academic achievement. Although the groups were randomly assigned to the control and the experimental groups, the pre-test results revealed that the groups were not different from each other in terms of their academic achievement at the beginning of the implementation. After the implementation, there is a significant difference in terms of academic achievement in favor of the experimental group. This implies that POE had a positive and significant effect on students' academic achievement. Considering that POE provides a discussion environment in which students actively involve in learning process, are able to share their opinions, and receive feedback, which ensures academic achievement (Kozcu-Çakır, Güven & Özdemir, 2017), this finding was expected and confirmed previous studies (Aydın, 2010; Mısır, 2009; Hilario, 2015; Sreerekha, Arun & Swapna, 2016; Farida, Waluyo & Fikr, 2018; Arsy, Pratesyo & Subali, 2020). More specifically, Teerasong and colleagues (2010) found that POE enables students to easily grasp science-related concepts, encourage them to construct their own knowledge, and improve their attitudes towards science. In addition, Wu and Tsai (2005) stated that POE contributed to the improvement of students' understanding of the concepts, enriched their information process skills, and enabled them to understand the experiments in school. Moreover, Keeratichamroen and colleagues (2007) assert that POE causes contradictions in students' mind as they learn new concepts and these contradictions encourage students to compare their predictions with their observations, which results in meaningful learning.

Another critical finding of the study is related to students' scientific process skills. Although the students in the control and experimental groups were equivalent according to their pre-test results, a significant difference was observed in the post-test scores in favor of the students in the experimental group. Similar results were obtained in the studies conducted by Adebayo and Olufunke (2015), and Widawati, Aznam and Purtad (2020). More specifically, Palmer (1995) asserts that POE is more effective in younger age groups comparing with middle school and high school students in terms of prediction, observation and explanation and argues that POE is an effective way not only teaching scientific concepts to children but also advance their scientific process skills. Palmer (1995) explains his rationale by stating that due to their age group, young children tend to communicate and explain their thoughts verbally rather than writing; therefore, POE is more suitable for younger age groups. Future research should consider to analyze the effects of POE on all age groups including K-12 and university level.

The last finding of the study is about students' attitudes towards science. There was no difference between the groups at the beginning of the implementation in terms of their attitudes. At the end of the implementation, although there was a difference between the groups in favor of the experimental group, this difference was not statistically significant. Akgün, Tokur and Özkara (2013) and Aydın (2010) found similar results and, in both studies, the researchers linked the duration of their implementation with the insignificant change in students' attitudes. They considered the duration of their implementation as a limitation to positively change their participants' attitude towards science. Moreover, Akgün and colleagues (2013) stated that use of POE in only one science concept or unit was not enough to affect students' attitude towards science. Duration and concept/unit selection were also the limitations of the current study. Despite the findings of these studies, there exist other studies that revealed positive effects of POE on students' attitudes towards science (Acar Şeşen & Mutlu, 2016; Erdem Özcan, 2019). In those studies, the implementation lasted about eight to ten weeks, which may be considered as a reason for the improvement in students' attitudes. Therefore, future studies should incorporate longer implementations and include various concepts in science as well as in other concepts from different disciplines to examine POE's effectiveness.

Limitations of the Study

There exist three limitations in the current study. The first one is related to the sample. This study included only 32 fourth grade students. Therefore, the findings may not be generalize to all population. More research should be conducted in crowded classrooms from different regions in order to generalize POE's effects on students' academic achievement, scientific process skills, and attitude towards science. The second limitation is related to the variables. This study examined the effect of POE on students' academic achievement, scientific process skills, and attitudes towards science. Future research should consider incorporation of different variables including gender, teachers' and students' experiences with POE, and/or use of team-works in order to examine the effects of POE. The last limitation is related to the data collection tools. In this study, quantitative research method was employed. In order to ensure the results, qualitative research method should be considered. Specifically, observations during the use of POE and interviews with students and teachers may provide more information about the use of POE in terms of practice and theory.

REFERENCES

Acar Şeşen, B., & Mutlu, A. (2016). Predict-Observe-Explain tasks in chemistry laboratory: pre-service elementary teachers' understanding and attitudes. *Sakarya University Journal of Education*, *6*(2), 184 208.

Adebayo, F., & Olufunke, B.T. (2015). Generative and Predict-Observe-Explain instructional strategies: towards enhancing basic science practical skills of lower primary school pupils. *International Journal of Elementary Education, 4*(4), 86-92.

Akgün, A., Tokur, F. & Özkara. (2013). TGA stratejisinin basınç konusunun öğretimine olan etkisinin incelenmesi. *Amasya Üniversitesi Eğitim Fakültesi Dergisi*, *2*(2), 348-369.

Arslan, A. (2013). *Araştırma-Sorgulama ve model tabanlı araştırma-sorgulama ortamlarında öğretmen adaylarının bilimsel süreç becerilerinin ve kavramsal değişim süreçlerinin incelenmesi* (Yüksek Lisans Tezi). Marmara Üniversitesi Eğitim Bilimleri Enstitüsü, İstanbul.

Arsy, H. I., Prasetyo, A. P. B., & Subali, B. (2020). Predict-Observe-Explain strategy with group investigation effect on students' critical thinking skills and learning achievement. *Journal of Primary Education*, *9*(1), 75–83.

Aydın, M. (2010). *Fen ve teknoloji öğretiminde tahmin-gözlem-açıklama tekniğinin kullanımının kavram yanılgılarının giderilmesine ve öğrenci başarısına etkisinin araştırılması* (Yüksek Lisans Tezi). Zonguldak Karaelmas Üniversitesi Sosyal Bilimler Enstitüsü, Zonguldak.

Aydoğdu, B. & Karakuş, F. (2015). İlkokul öğrencilerine yönelik temel beceri ölçeğinin Türkçe'ye uyarlama çalışması. *Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi*, *1*(34), 105-131.

Bilen, K. (2009). *Tahmin Et-Gözle-Açıla yöntemine dayalı laboratuvar uygulamalarının öğretmen adaylarının kavramsal başarılarına, bilimsel süreç becerilerine, tutumlarına ve bilimin doğası hakkındaki görüşlerine etkisi* (Doktora Tezi). Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

Çepni, S. (2011). *Araştırma ve proje çalışmalarına giriş*. Trabzon: Celepler Matbaacılık.

Creswell, J. W. (2003). *Research design: Qualitative, quantitave and mixed methods approaches*. (2nd ed.) Thousand Oaks: Sage.

Erdem Özcan, G. (2019). *İlkokul dördüncü sınıf fen bilimleri dersinde tahmin gözlem açıklama stratejisine dayalı öğretimin akademik başarı tutum ve kalıcılığa etkisi* (Yüksek Lisans Tezi). Kastamonu Üniversitesi Sosyal Bilimler Enstitüsü, Kastamonu.

Farida, D., Waluyo, J., & Fikr, K. (2018). The effect of POE learning models (Prediction, Observation, and Explanation) with probing-prompting techniques on the student's cognitive learning outcomes of SMA Muhammadiyah 3 Jember. *Pancaran Pendidikan FKIP Universitas Jember*, *7*(3), 51-56.

Geban, Ö., Ertepınar, H., Yılmaz, G., Altın, A., & Sahbaz, F. (1994). Bilgisayar destekli eğitimin öğrencilerin fen bilgisi başarılarına ve fen bilgisi ilgilerine etkisi. *Birinci Ulusal Fen Bilimleri Eğitimi Sempozyumu Bildiri Özetleri Kitabı*, Dokuz Eylül Üniversitesi, İzmir.

Göktürk, M. (2015). *Fen ve teknoloji dersinde TGA stratejisi ile zenginleştirilmiş animasyon destekli öğretimin akademik başarıya, tutuma ve kalıcılığa etkisinin incelenmesi* (Yüksek Lisans Tezi). Ağrı İbrahim Çeçen Üniversitesi Fen Bilimleri Enstitüsü, Ağrı.

Hançer, A. H. (2009). Fen eğitiminde yapılandırmacı yaklaşıma dayalı bilgisayar destekli öğrenmenin problem çözme becerisine etkisi. *Gazi Eğitim Fakültesi Dergisi*, *29*(1), 55-72.

Harman, G. (2015). Tahmin Gözlem Açıklama (TGA) yöntemine dayalı bir laboratuvar etkinliği: Hücre zarından madde geçişi. *International Journal of New Trends in Arts, Sports & Science Education*, *4*(1), 23-36.

Hilario, J. S. (2015). The Use of Predict-Observe-Explain-Explore (POEE) as a new teaching strategy in general chemistry-laboratory. *International Journal of Education and Research*, *3*(2), 37-48.

İnci, Ş. (2015). *Yapılandırmacı yaklaşıma göre tasarlanan ilköğretim programında velilerin rollerini yerine getirme düzeyi* (Yüksek Lisans Tezi). Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

Kalaycı, N. (2014). *Yapılandırmacı yaklaşımın sınıf yönetimi ve öğrenme sürecine yansımaları* (Yüksek Lisans Tezi). İstanbul Sabahattin Zaim Üniversitesi Sosyal Bilimler Enstitüsü, İstanbul

Kara, E. (2017). *Tahmin et- gözle-açikla stratejisine dayalı fen öğretiminin ortaokul 5. sınıf öğrencilerinin bilimsel süreç becerilerine ve başarısına etkisinin araştırılması* (Yüksek Lisans Tezi). Marmara Üniversitesi Eğitim Bilimleri Enstitüsü, İstanbul.

Karaçallı, S. (2011). *İlköğretim 4. sinif fen ve teknoloji dersinde proje tabanli öğrenme yönteminin akademik başarıya, tutuma ve kalıcılığa etkisi* (Yüksek Lisans Tezi). Burdur Mehmet Akif Ersoy Üniversitesi Sosyal Bilimler Enstitüsü, Burdur.

Karasar, N. (2002). *Bilimsel araştırma yöntemleri*. Ankara: Nobel Yayınları.

Karatekin, P. (2012). *Fen ve teknoloji öğretmen adaylarının biyoloji laboratuvarlarında TGA tekniğinin öğrencilerin başarı, tutum ve bilimsel süreç becerileri üzerine etkisi* (Yüksek Lisans Tezi). Celal Bayar Üniversitesi Fen Bilimleri Enstitüsü, Manisa.

Kearney, M. & Treagust, D. F. (2001). Constructivism as a referent in the design and development of a computer program using interactive digital video to enhance learning in physics. *Australian Journal of Educational Technology*, *17*(1), 64-79.

Keeratichamroen, W., Panijpan, B. & Dahsah, C. (2007). Using the Predict-Observe-Explain (POE) to promote students' learning of tapioca bomb and chemical reactions. Mahidol University, *Annual Research Abstracts,* 35, 563

Kırılmazkaya, G., & Kırbağ Zengin, F. (2015). Tahmin Et-Gözle-açıkla yönteminin ortaokul öğrencilerinin akademik başarılarına ve fene karşı tutumlarına etkisinin incelenmesi. *Uluslararası Sosyal Araştırmalar Dergisi*, *8*(41), 975-982.

Köseoğlu, F., Tümay, H., & Kavak, N. (2002). Yapılandırıcı öğrenme teorisine dayanan etkili bir öğretim yöntemi-tahmin et-gözle-açıkla-"Buz ile su kaynatılır mı?" *V. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi,* ODTÜ, Aralık, Ankara, Bildiriler Kitabı, 670-675.

Kozcu-Çakır, N., Güven, G., & Özdemir, O. (2017). TGA stratejisinin genel biyoloji laboratuvar uygulamalarında etkililiğine ilişkin bir araştırma. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*, *17*(4), 2014-2035.

Mısır, N. (2009). *Elektrostatik ve Elektrik Akımı Ünitelerinde TGA yöntemine dayalı olarak geliştirilen etkinliklerin uygulanması ve etkililiğin incelenmesi* (Yüksek Lisans Tezi). Karadeniz Teknik Üniversitesi Fen Bilimleri Enstitüsü, Trabzon.

Nurhuda, N. Lukito, A. & Djalil, M. D. (2018). Effectiveness of cooperative learning instructional tools with predict-observe-explain strategy on the topic of cuboid and cube. IOP Conf. Series: *Journal of Physics: Conf. Series*, 947, 1-5.

Özçelik, H. (2019). *Kavram karikatürleri ile desteklenen tahmin et-gözle-açıkla (TGA) yönteminin ortaokul öğrencilerinin sorgulama becerileri, bilimsel süreç becerileri ve kavram öğrenmelerine etkisi* (Yüksek Lisans Tezi). Marmara Üniversitesi Eğitim Bilimleri Enstitüsü, İstanbul.

Özyılmaz, G. A. (2008). *İlköğretimde analojiler kavram karikatürleri ve tahmin-gözlem-açiklama teknikleriyle desteklenmiş fen ve teknoloji eğitiminin öğrenme ürünlerine etkisi* (Doktora Tezi). Dokuz Eylül Üniversitesi Eğitim Bilimleri Enstitüsü, İzmir.

Padilla, M., Cronin, L., & Twiest, M. (1985). The development and validation of the test of basic process skills. *Paper presented at the Annual Meeting of the National Association for Research in Science Teaching,* French Lick, IN.

Palmer, D. (1995). The POE in the primary school: An evaluation. *Research In Science Education*, *25*(3), 323-332.

Rini, A. P., Suryani, N. & Fadhilah, S. S. (2019). Development of the predict observe explain (POE)-based thematic teaching materials. *International Journal of Educational Research Review*, *4*(1),1-7

Sağırekmekçi, H. (2016). *"Tahmin-Gözlem-Açıklama''(TGA) stratejisine dayalı fen ve doğa etkinliklerinin, okul öncesi öğrencilerinin bilimsel süreç becerilerine ve bilişsel alan yeteneklerine etkisi* (Yüksek Lisans Tezi). Mustafa Kemal Üniversitesi Fen Bilimleri Enstitüsü, Hatay.

Sreerekha, S., Arun, R. R., & Swapna, S. (2016). Effect of Predict-Observe-Explain strategy on achievement in chemistry of secondary school students. *International Journal of Education & Teaching Analytics I*, *1*(1), 1-5.

Teerasong, S., Chantore, W., Ruenwongsa, P., & Nacapricha, D. (2010). Development of a predict-observe-explain strategy for teaching floe injection at undergraduate chemistry. *The International Journal of Learning*, *17*(8), 137-150.

Tekin, S. (2008). Tahmin-Gözlem-Açıklama stratejisinin fen laboratuvarında kullanımı: Kükürdün molekül kütlesi nedir?. *Erzincan Eğitim Fakültesi Dergisi*, 10, 2.

Tokur, F. (2011). *TGA stratejisinin fen bilgisi öğretmen adaylarının bitkilerde büyüme-gelişme konusunu anlamalarına etkisi* (Yüksek Lisans Tezi). Adıyaman Üniversitesi Fen Bilimleri Enstitüsü, Adıyaman.

Turgut, H. (2002). *Fen bilgisi öğretiminde yapılandırmacı öğretim yaklaşımı ile modellendirilmiş etkinliklerin öğrencide kavramsal gelişme ve başarıya etkisi* (Yüksek Lisans Tezi). Marmara Üniversitesi Eğitim Bilimleri Enstitüsü, İstanbul.

Ünal, Ç., & Çelikkaya, T. (2009). Yapılandırmacı yaklaşımın sosyal bilgiler öğretiminde başarı, tutum ve kalıcılığa etkisi (5. sınıf örneği). *Atatürk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *13*(2), 197-212.

Wu, Y. T., & Tsai, C. C. (2005). Development of elementary school students' cognitive structures and information processing strategies under long-term constructivist-oriented science instruction. *Science Education*, 89, 822– 846.