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THE EFFECT OF PREDICT-OBSERVE-EXPLAIN TECHNIQUE ON THE UNDERSTANDINGS OF GRADE 11 STUDENTS ABOUT THE GASES

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Abstract
The purpose of the present study is to investigate the effect of the activities based on Predict-Observe-Explain (POE) technique on grade 11 students' conceptual understanding and alternative conceptions of the gases. The study was conducted in an Anatolian high school in Trabzon and used the quasi-experimental design. Two classes at the school were randomly selected for the study. While one of the classes was randomly assigned as experimental group (N=36), the other was determined as control group (N=37). Gases Concept Test (GCT) consisting of 20 multiple choice items was used. The test' reliability coefficient (KR-20) was found 0.84. Eight activities based on POE technique were developed and applied to the experimental group students. On the other hand, the control group students were taught by traditional approach. The results indicated that the experimental group students taught with the POE technique showed a higher success than the control group students.

Keywords: Chemistry education, POE technique, Gases.

INTRODUCTION

Many studies in the science literature have shown that students have difficulty in understanding many basic chemistry concepts and come to chemistry classes with knowledge (alternative conceptions) which is inconsistent with the scientific conceptions (Özmen, Demircioğlu & Demircioğlu, 2009). This situation is also similar for many basic science concepts. Alternative conceptions may hinder subsequent learning because students often do not know that the knowledge they have is wrong and try to build new knowledge on these erroneous conceptions. There have been a number of studies on students' alternative conceptions related to many basic chemistry concepts, such as particulate nature of matter (Abraham, Williamson & Westbrook, 1994), gases (Demircioğlu & Yadigaroglu, 2014), equilibrium (Gussarsky & Gorodetsky, 1990), chemical bonding (Coll & Treagust, 2003), and electrochemistry (Garnett & Treagust, 1992). Of these, the gases and related concepts are investigated in the present study. The gas concepts are one of the fundamental and difficult concepts of chemistry. Students at all age groups have difficulty in understanding these concepts (Demircioğlu & Yadigaroglu, 2014, Demircioğlu, Tütüncü & Demircioğlu, 2016; Gürses et al., 2012). Demircioğlu, Tütüncü and Demircioğlu (2016) used a survey method to determine students' understanding levels and alternative ideas about gas concepts. According to the results of their research, it was found that the understanding level of the students was about 50%, and they were found to have alternative ideas at important and varying rates. The main reason for this difficulty is that the gas concepts

require a sound understanding of the particulate nature of matter which is not visible and abstract. This situation makes it difficult for the student to understand the concept. Stavy (1990) found that students think that "the gases do not have mass", and "the gas state of a matter is lighter than its liquid and solid state". Novick and Nussbaum (1981) and Novick and Nussbaum (1978) found that students believe that there is something between the gas particles such as other gases, dust, and unknown vapors. Water molecules in the gas phase are the largest" (Griffiths and Preston, 1992), "the size of a molecule depends on its temperature" (Lin, Cheng & Lawrenz, 2000)". Alternative conceptions are very resistant to ordinary forms of instruction (lectures, note-taking, discovery learning, or simply reading texts) because they are meaningful and logical for the students. In order to be able to correct their alternative ideas, many different methods have been tried on different chemistry topics in the literature. Some of these methods can be listed as; analogy (Türk, Ayas & Karslı, 2010), conceptual change texts (Günay, 2005), POE technique (Sreerekha, 2016), PDEODE strategy (Demircioğlu, 2017), and animations (Al-Balushi, 2017). The POE strategy was developed by White and Gunstone (1992) to uncover individual students' predictions, and their reasons for making these, about a specific event. Also, this technique supports both constructivist approach and conceptual change model. Research has shown that the POE are a useful teaching technique for determining students' alternative conceptions, and improving the conceptual understanding of students (Coştu, Ayas, & Niaz, 2012; Kala, Yaman & Ayas, 2012; Kearney, 2004; Kearney et al., 2001).

THE PURPOSE OF THE STUDY

The purpose of the study is to investigate the effect of the activities based on Predict-Observe-Explain (POE) technique on grade 11 students' conceptual understanding and alternative conceptions of the gases.

1. What are the experimental and control group students' alternative conceptions about gases both before and after the treatment?
2. Is there a statistically significant difference between the experimental group and the control group in term of students' conceptual understanding of the gas concept after the treatment?

METHOD

The study used the quasi-experimental method because school authorities in Turkey do not allow the researchers to constitute new classrooms for experimental purposes. A pre-test-post-test non-equivalent groups design, one of research designs of the quasi-experimental method, was selected for this study. Two grade 11 classes at the school where the study was conducted were randomly selected for the study groups. While one of the classes was randomly assigned as experimental group, the other was determined as control group. The experimental group students were instructed by using POE technique while the control group students were taught with the traditional approach. Both groups were taught by the same teacher with over 10 years of teaching experience in chemistry education.

The Sample

The sample for the study consisted of 73 eleventh grade students from two intact classes of Fatih Sultan Mehmet Anatolian high school in Trabzon province of Turkey. One class (N = 36; 25 boys and 11 girls) was assigned as the experimental group (EG) and the other (N=37; 24 boys and 13 girls) was chosen as the control group (CG). The study was conducted during the spring semester of the academic year 2016-2017.

Gases Concept Test (GCT)

GCT consisted of 20 multiple-choice questions was applied to both groups as a pre-test and post-test. Apart from identifying the effectiveness of the POE technique, the GCT enabled us to identify any alternative conceptions about gases. While 2, 6, 9, 10, 11, 14, and 20th questions were developed by

the authors, the other questions were taken from the literature (Demircioğlu, Kurnaz & Erol, 2017; Demirel, 2015; Demirer, 2009; Yıldırım, 2010). Items 11 is given below as an example;

Item 11: You're holding three balloons, each of which is inflated with a different gas (oxygen, helium and methane gas) until the same pressure is reached in each balloon. Which of the following statements is correct? *(He=4, O_2=32, CH_4=16)*
a) The balloons have not equal volumes
b) The most particles are in the balloon filled with oxygen
c) The mass of each balloon is the same
d) The least particles are in the balloon filled with helium
e) The number of particles in the balloons is equal to each other

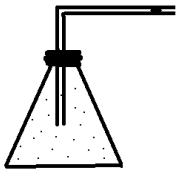
For content validity, the GCT was examined by a group of experts consisting of two university chemistry educators and two high school chemistry teachers who have been teaching for over thirteen years at the central high school in the city of Trabzon. For validity and reliability, the GCT was piloted with 52 grade 10 students of a school which was not part of the sample. Any items that were not clear were changed to reduce ambiguity. Its reliability coefficient (KR-20) for the pilot study was found to be 0.84, while this value was 0.82 for the real study. The concepts investigated by each item in the GCT are presented in Table 1.

Table 1: Concepts Investigated in the GCT

Concepts	Item numbers
Pressure	1, 2, 5, 7, 14, 16, 20
Volume	1, 5, 6, 8, 10, 12, 14, 20
Ideal Gas-Real Gas	6, 13, 14
Diffusion	15, 17, 18, 19
The mole-Pressure	3, 9, 10, 11

The treatment
Firstly, the CAT was administered to both groups as the pretest one week before the intervention. In the intervention phase, EG students were taught by the teacher using POE activities for three weeks (6 lesson hours). Eight activities were determined by the researchers from different sources. Activity 4 is given below as an example;

Activity 4:



The used materials: Erlen, rubber stopper, bent glass tube, container, cold water, and mercury

As in the figure above, place the bent glass tube into the top of the erlen by using the rubber stopper. There is some mercury in the bent glass tube as in the figure. Predict what will happen to the mercury in the tube if the apparatus is placed in a container filled with ice? Write down your predictions.

.....
.....

Activity: *Place the apparatus at the figure into a container filled with ice.* And then observe the mercury in the glass tube. Write down the results of your observation.
Observation result:.....
Compare your prediction to the result of your observation: .....

As seen from the Activity 4, the POE consists of three steps, Predict, Observe, and Explain. In the *Predict* step, knowledge about event is given to students and the students are asked to predict the

outcome of this event. In the *Observe* step, student observes how the event happens. It is important that it constitute a conflict. In the *Explain* step, the students think about differences between their prediction and observation. If there is a conflict between their prediction and observation, they try to correct it. In a typical instructional sequence, firstly, students were divided into six groups. The worksheet related to the POE activities was handed out to students and they were asked to write down their predictions about the result of event or experiment in the worksheets. Then, while the experiment or event was demonstrated by the teacher, students observed carefully and record the results of their observation. Finally, teacher asked the students to compare their prediction to the results of their observation and to discuss the whole process.

THE RESULTS

In the analysis of the GCT, firstly, the test score of each student in both groups were calculated. For this aim, 1 point is assigned for each correct answer and 0 point is assigned for each incorrect answer. As a result, the maximum score a student can take from the test is 24. The pre-test and post-test scores of the groups were compared with independent t-test to determine whether a statistically significant mean difference existed between two groups. The pre-test results of the experimental and control group are given in the Table 2.

Table 2: The Pre-Test Results of the Experimental and Control Group

Item no	Group	A		B		C		D		E		Empty	
		f	%	f	%	f	%	f	%	f	%	f	%
1	EG	4	11.1	6	16.6	2	5.6	18	50.0	5	13.8	1	2.8
	CG	0	0	15	40.5	2	5.4	18	48.6	2	5.4	0	0
2	EG	0	0	2	5.6	6	16.6	12	33.3	13	36.1	3	8.3
	CG	2	5.4	5	13.5	4	10.8	6	16.2	20	54.0	0	0
3	EG	2	5.6	9	25.0	9	25.0	9	25.0	2	5.6	5	13.8
	CG	4	10.8	14	37.8	1	2.7	3	8.1	6	16.2	9	24.3
4	EG	16	44.4	1	2.8	5	13.8	6	16.6	7	19.4	1	2.8
	CG	15	40.5	1	2.7	0	0	14	37.8	2	5.4	5	13.5
5	EG	2	5.6	19	52.7	3	8.3	1	2.8	11	30.5	0	0
	CG	4	10.8	20	54.0	0	0	4	10.8	7	18.9	2	5.4
6	EG	8	22.2	16	44.4	8	22.2	0	0	2	5.5	2	5.6
	CG	13	35.1	2	5.4	17	45.9	1	2.7	2	5.4	2	5.4
7	EG	1	2.8	2	5.6	13	36.1	4	11.1	13	36.1	3	8.3
	CG	5	13.5	5	13.5	9	24.3	1	2.7	11	29.7	6	16.2
8	EG	7	19.4	5	13.8	1	2.8	13	36.1	8	22.2	2	5.6
	CG	6	16.2	2	5.4	3	8.1	21	56.7	3	8.1	1	2.7
9	EG	9	25.0	6	16.6	6	16.6	9	25.0	2	5.6	4	11.1
	CG	4	10.8	1	2.7	1	2.7	17	45.9	5	13.5	9	24.3
10	EG	4	11.1	10	27.7	9	25.0	7	19.4	2	5.6	4	11.1
	CG	1	2.7	3	8.1	14	37.8	4	10.8	6	16.2	9	24.3
11	EG	17	47.2	6	16.6	3	8.3	4	11.1	3	8.3	3	8.3
	CG	11	29.7	9	24.3	4	10.8	3	8.1	2	5.4	8	21.6
12	EG	15	41.6	9	25.0	7	19.4	2	5.6	1	2.8	2	5.6
	CG	9	24.3	3	8.1	11	29.7	9	24.3	3	8.1	2	5.4
13	EG	3	8.3	10	27.7	9	25.0	4	11.1	5	13.8	5	13.8
	CG	6	16.2	7	18.9	4	10.8	2	5.4	6	16.2	12	32.4
14	EG	4	11.1	10	27.7	7	19.4	10	27.7	1	2.8	4	11.1
	CG	5	13.5	4	10.8	5	13.5	11	29.7	2	5.4	10	27.0
15	EG	16	44.4	3	8.3	6	16.6	3	8.3	6	16.6	2	5.6
	CG	21	56.7	2	5.4	5	13.5	2	5.4	4	10.8	3	8.1

16	EG	0	0	8	22.2	2	5.6	2	5.6	22	61.1	2	5.6
	CG	1	2.7	8	21.6	1	2.7	3	8.1	12	32.4	12	32.4
17	EG	9	25.0	2	5.6	9	25.0	6	16.6	7	19.4	4	11.1
	CG	8	21.6	9	24.3	4	10.8	7	18.9	4	10.8	5	13.5
18	EG	5	13.8	1	2.8	10	27.0	13	36.1	2	5.6	5	13.8
	CG	2	5.4	0	0	12	32.4	6	16.2	2	5.4	15	40.5
19	EG	26	72.2	4	11.1	0	0	3	8.3	1	2.8	2	5.6
	CG	13	35.1	5	13.5	3	8.1	7	18.9	3	8.1	6	16.2
20	EG	22	61.1	0	0	7	19.4	4	11.1	1	2.8	2	5.6
	CG	5	13.5	3	8.1	3	8.1	5	13.5	12	32.4	9	24.3

Percentages of correct answers given to the questions ranged 2.8% to 72.2% for EG students and from 5.4% to 56.7% for CG students, as could be seen in Table 2. The distractors in the GCT indicated alternative conceptions and insufficient understandings of the students. From this, it could be said that the students in both groups held a number of alternative conceptions about gases. This finding supports the results of other studies in the literature (Demircioğlu, Kurnaz & Erol, 2017; Yadigaroğlu & Demircioğlu, 2012). As seen Table 3, mean score of EG students was 5.86 and standard deviation 2.78 while mean score of CG students was 6.78 and standard deviation 3.18. The average of the control group is higher than EG. However, as a result of the t test, it was determined that this mean difference was not significant ($t(71)= 1.99$; $p=0.19$). Based on this result, both group students can be regarded as equivalent in terms of prior knowledge levels related to gas concepts. Based on this result, it was assumed that both group students were similar or equal in terms of prior knowledge levels related to gas concepts.

Tablo 3: The Pre- and Post-Test Results of the Experimental and Control Group

		N	Mean	SD	df	t	p
Pre-test	EG	36	5.86	2.78	71	1.99	0.19
	CG	37	6.78	3.18			
Post-test	EG	36	13.42	3.98	71	4.58	0.001
	CG	37	9.57	3.14			

After the treatment, the GCT was applied to both group students to new understanding levels and the ACs they continued to keep. The post-test results of the experimental and control group are given in the Table 4.

Table 4: The Post-Test Results of the Experimental and Control Group

Item no	Group	**A**		**B**		**C**		**D**		**E**		**Empty**	
		f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
1	EG	1	2.8	4	11.1	2	5.6	26	72.2	2	5.6	1	2.8
	CG	1	2.7	1	2.7	1	2.7	28	75.6	6	16.2	0	0
2	EG	0	0	2	5.6	2	5.6	1	2.8	31	86.1	0	0
	CG	0	0	0	0	6	16.2	6	16.2	25	67.5	0	0
3	EG	0	0	33	91.6	2	5.6	1	2.8	0	0	0	0
	CG	0	0	26	70.2	1	2.7	6	16.2	1	2.7	3	8.1
4	EG	2	5.6	0	0	0	0	34	94.4	0	0	0	0
	CG	9	24.3	1	2.7	2	5.4	21	56.7	2	5.4	2	5.4
5	EG	1	2.8	25	69.4	0	0	1	2.8	9	25	0	0
	CG	2	5.4	22	59.4	1	2.7	3	8.1	8	21.6	1	2.7

6	EG	1	2.8	6	16.6	29	80.5	0	0	0	0	0	0
	CG	14	37.8	3	8.1	16	43.2	3	8.1	1	2.7	0	0
7	EG	15	41.7	1	2.8	5	13.8	5	13.8	8	22.2	2	5.6
	CG	17	45.9	0	0	12	32.4	0	0	4	10.8	4	10.8
8	EG	7	19.4	1	2.8	1	2.8	22	61.1	4	11.1	1	2.8
	CG	7	18.9	1	2.7	2	5.4	21	56.7	5	13.5	1	2.7
9	EG	4	11.1	5	13.8	9	25	16	44.4	1	2.8	1	2.8
	CG	4	10.8	3	8.1	2	5.4	23	62.1	2	5.4	3	8.1
10	EG	2	5.6	4	11.1	28	77.8	0	0	1	2.8	1	2.8
	CG	2	5.4	17	45.9	4	10.8	10	27	2	5.4	2	5.4
11	EG	15	41.6	7	19.4	2	5.6	4	11.1	7	19.4	1	2.8
	CG	12	32.4	18	48.6	1	2.7	3	8.1	1	2.7	2	5.4
12	EG	8	22.2	3	8.3	5	13.8	17	47.2	1	2.8	2	5.6
	CG	12	32.4	4	10.8	10	27	6	16.2	2	5.4	3	8.1
13	EG	3	8.3	6	16.6	18	50	6	16.6	2	5.6	1	2.8
	CG	5	13.5	18	48.6	10	27	1	2.7	1	2.7	2	5.4
14	EG	0	0	5	13.8	21	58.3	7	19.4	1	2.8	2	5.6
	CG	6	16.2	1	2.7	4	10.8	4	10.8	16	43.2	6	16.2
15	EG	24	66.7	0	0	5	13.9	1	2.8	6	16.6	0	0
	CG	27	72.9	1	2.7	5	13.5	0	0	2	5.4	2	5.4
16	EG	1	2.8	5	13.8	2	5.6	0	0	28	77.8	0	0
	CG	5	13.5	1	2.7	7	18.9	1	2.7	19	51.3	4	10.8
17	EG	23	63.8	4	11.1	2	5.6	7	19.4	0	0	0	0
	CG	25	67.5	3	8.1	1	2.7	4	10.8	0	0	4	10.8
18	EG	3	8.3	2	5.6	5	13.8	26	72.2	0	0	0	0
	CG	0	0	3	8.1	8	21.6	14	37.8	3	8.1	9	24.3
19	EG	34	94.4	1	2.8	0	0	1	2.8	0	0	0	0
	CG	20	54	7	18.9	1	2.7	2	5.4	1	2.7	6	16.2
20	EG	1	2.8	1	2.8	8	22.2	2	5.6	24	66.7	0	0
	CG	6	16.2	0	0	1	2.7	0	0	25	67.5	5	13.5

In the post-tests, percentages of correct answers ranged 19.4% to 94.4% for EG students and from 2.7% to 75.6% for CG students (Table 4). The EG students showed the highest performance (94.4%) in items 4 (about ideal gas) and 19 (about distribution of a gas in a closed container) and the lowest performance in item 11 (this item is given above). On the other hands, the CG students had the highest performance (75.6%) in items 15 (about diffusion) and the lowest performance in item 11 (this item is given above). As seen Table 3, mean score of EG students was 13.42 and standard deviation 3.98 while mean score of CG students was 9.57 and standard deviation 3.14. The t-test results indicated that this mean difference was statistically significant ($t(71)= 4.58$; $p=0.001$). This result showed that the EG students were taught with the POE activities were more successful than the CG students instructed with the traditional approach. In other words, it can be said that the POE activities were more affective on students' understanding of gas concepts than the traditional activities. This result supports to the results of the studies in the literature (Coştu, Ayas & Niaz, 2012; Kala, Yaman & Ayas, 2012; Kearney, 2004; Kearney et al., 2001). In the study, Dial et al. (2009) suggested that POE technique improves students' conceptual development of gases.

The alternative conceptions that students in both groups show in the pre and post test are presented in the Table 5 below.

Table 5: The Alternative Conceptions that Students in both Groups Show in the Pre- and Post-Test

Students' alternative conceptions		Pre-test				Post-test			
		EG		CG		EG		CG	
		f	%	f	%	f	%	f	%
AC1	There is air between the particles of a pure gas	16	44.4	15	40.5	5.6	8.3	9	24.3
AC2	When the volume of an ideal gas is increased, the velocity of its molecules increases.	8	22.2	13	35.1	1	2.8	14	37.8
AC3	Hot air molecules are lighter than cold air molecules	13	36.1	9	24.3	5	13.8	12	32.4
AC4	Hot air molecules grow and cold air molecules shrink.	13	36.1	11	29.7	8	22.2	4	10.8
AC5	Two balloons, each of which is filled with the same mass of gas (one balloon contains hydrogen gas, the other balloon contains oxygen gas) have equal volumes.	9	25	4	10.8	4	11.1	4	10.8
AC6	The gas particles in the balloons are located near the center of the balloon	2	5.6	9	24.3	7	19.4	3	8.1
AC7	If a gas in the container is heated, the gas particles are collected in one part of the container (below, in the middle, on the edge, above)	6	16.6	7	18.9	9	25.0	4	10.8
AC8	In a gas mixture in a container, gas molecules with larger mass are collected in the bottom of the container while gas molecules with smaller mass are collected in the top of the container	10	27.7	12	32.4	7	19.4	8	21.6
AC9	Its weight increases when a gas is heated	10	27.7	7	18.9	8	22.2	2	5.4
AC10	When the volume of an ideal gas is doubled, the average speed of the molecules doubles.	8	22.2	13	35.1	1	2.8	14	37.8

As seen Table 5, percentages of alternative conceptions of EG students ranged from 5.6% to 44.4 in pre-test while alternative conceptions of CG students ranged from 10.8% to 40.5%. On the other hands, percentages of alternative conceptions of EG students ranged from 2.8% to 25.0 in post-test while alternative conceptions of CG students ranged from 5.4% to 37.8% (Table 11). In the EG, the percentage values of student alternative conceptions in the Table 11 decreased except for the AC6 and AC7 after the treatment. In the CG, the percentage value of the AC5 did not change, AC2, AC3, and AC10 increased, and the other ACs decreased. Although the pre-conceptions of the students were taken into account in the experimental group, the alternative conceptions of the students were not completely corrected. Some students in EG keep to hold their alternative conceptions even after the treatment (see Table 5). It is emphasized that this situation may also occur in the studies in the literature (Hewson & Hewson, 1983). The reason for this is that the ACs are logical and plausible for the student, they are resistant to change.

CONCLUSION AND RECOMMENDATION

This study tried to determine the effectiveness of the POE activities on students' understanding of gas concepts, and in overcoming alternative conceptions for these concepts. Since the main purpose of instruction is to facilitate students integrate new knowledge to their pre-existing knowledge, it could be inferred that the POE activities used in the present study were more effective than the traditional activities, *i.e.*, note-taking and teacher's explanations. The results of the present study indicated that the POE activities did not attract the attention of some students while attracting more attention of some students. As a result of this, while the POE activities are effective in overcoming some students'

alternative conceptions of the gas concept, they are not effective for some other students. These students in the EG continued to keep their alternative conceptions about gas concept after the treatment. The POE technique, which consists of three steps (predict, observe and explain), requires students to make predictions, observations, and detailed explanations. Consequently, these processes lead the students to think more and to develop some of their scientific process skills.

More studies on the POE technique could be designed about other basic concepts of chemistry to explore students' alternative conceptions and correct them. Teachers should take into account prior knowledge and alternative ideas of the students as starting points of teaching as they teach new concepts because these ideas influence students' subsequent learning. Unfortunately, teachers generally adopt the transmission of knowledge as the appropriate approach to teach, without considering students' prior knowledge. They should use teaching methods that helps the students to question their preconceptions, and motivates them to learn, and aim to correct alternative ideas such as POE technique, 5Es model, and so on. The teaching models and techniques aiming at conceptual change and their applications should be taught to student teachers and chemistry teachers. In addition to the available materials, teaching materials based on POE technique that may help to remedy students' alternative conceptions should be devised and presented to teachers' usage.

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