THE EFFECTS OF ARGUMENT-DRIVEN INQUIRY INSTRUCTIONAL MODEL ON 10TH GRADE STUDENTS' UNDERSTANDING OF GASES CONCEPTS

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ABSTRACT

THE EFFECTS OF ARGUMENT-DRIVEN INQUIRY INSTRUCTIONAL MODEL ON 10TH GRADE STUDENTS' UNDERSTANDING OF GASES CONCEPTS

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The main purpose of this study was to seek whether there is a significant effect of Argument-Driven Inquiry (ADI) instructional model on 10th grade high school students' conceptual understanding and attitudes toward chemistry as compared to traditional chemistry instruction and to draw conclusion based on the evidence for students' conceptual understandings of gases concepts and attitude toward chemistry between the experimental and traditional groups. The sample of this study consisted of 157 tenth grade students from one public high school at Ankara. Six intact classes of same teacher were participated in this study. The classes were randomly assigned as experimental group and control group. The control groups were instructed by using traditional chemistry instruction, while the experimental groups were instructed by using ADI instructional model. The study was conducted during seven weeks on gases concepts included in the states of matter unit. Gases Concept Test-I (GCT-I), a two tiered Gases Concept Test- II (GCT-II), and Attitude Scale toward Chemistry (ASTC) was administered to all participant as pre-posttests. Moreover, Argumentativeness Scale toward Argumentation (ASTA) was applied only experimental group students before and after the treatment in order to measure a person's tendency to pursue or avoid of argumentation in argumentative situations. After the treatment, semi-structured interviews were applied to 8 students in order to examine the students' conceptual understanding and alternative conceptions in gases concepts clearly. Further, MANCOVA was used to analyze the data and descriptive and inferential statistics were obtained. The results indicated that, experimental group students who were taught by ADI instructional model had statistically significant higher scores than control group students in terms of understanding gas concepts and also attitude toward chemistry. Similarly, the students from experimental group showed less alternative conceptions according to the results of two-tiered posttest after treatment. Students' interview results supported the inferential statistics. In addition, students' who taught ADI instructional model showed a significant increase of willingness to pursue of argumentation.

Keywords: Argument-Driven Inquiry Instructional Model, scientific argumentation, chemistry education, attitude toward chemistry, gas concepts, conceptual understanding, gender

ÖZ

ARGÜMANTASYONA DAYALI SORGULAYICI EĞİTİM MODELİNİN 10. SINIF ÖĞRENCİLERİNİN GAZ KAVRAMLARINI ANLAMALARINA ETKİSİ

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Bu çalışmanın amacı, onuncu sınıf öğrencilerinin gazlar konusundaki kavramsal anlamaları ve kimyaya karşı tutumları üzerine Argümantasyona Dayalı Sorgulayıcı eğitim(ADSE) modelinin etkisini geleneksel yöntemle karşılaştırarak incelemektir. Bu çalışmanın örneklemini Ankara'da bir devlet okulunda öğrenim gören 157 onuncu sınıf öğrencisi oluşturmaktadır. Bu çalışmada aynı öğretmene ait altı farklı sınıf yer almaktadır. Sınıflar deneysel ve kontrol grup olmak üzere rastgele atanmıştır. Kontrol gruptaki öğrenciler geleneksel yöntem ile eğitim görürken, deney grubundaki öğrenciler ADSE modeli ile eğitim görmüşlerdir. Çalışma yaklaşık yedi hafta sürmüş, bu sürede tüm öğrencilere Gazlar Kavram Testi-I, iki aşamalı Gazlar Kavram Testi-II ve Kimyaya Karşı Tutum Ölçeği ilk test ve son test olarak uygulanmıştır. Bunun yanı sıra, deney grubu öğrencilerine uygulama öncesi ve sonrası argümantasyon sürecine dâhil olma veya kaçınmaya yönelik eğilimlerini ölçmek amacı ile Tartışmacı Anketi uygulanmıştır. Uygulama sonrası ise 8 öğrenci ile gazlar konusundaki kavramsal anlamalarını ve kavram yanılgılarını derinlemesine incelemek için yarı- yapılandırılmış mülakatlar yapılmıştır. Toplanan verileri analiz etmek için çok değişkenli kovaryans analizi (MANCOVA) kullanılmıştır. Analiz sonuçlarına göre, ADSE ile eğitim gören öğrenciler gaz kavramlarını anlama ve kimyaya karşı tutumları bakımından kontrol grubu öğrencilerinden istatistiksel anlamlı olarak daha yüksek sonuçlar elde etmişlerdir. Aynı zamanda, deney grubu öğrencilerinin gaz kavramları ile ilgili daha az kavram yanılgısına sahip olduğu saptanmıştır. Öğrencilerin mülakat sonuçları bu bulguları desteklemektedir. Bunun yanı sıra, ADSE modeli ile eğitim gören öğrencilerin tartışmaya istekliliklerinde anlamlı bir artış gözlenmiştir.

Anahtar Kelimeler: Argümantasyona Dayalı Sorgulayıcı Eğitim Modeli, bilimsel tartışma, kimya eğitimi, kimyaya karşı tutum, gaz kavramları, anlama, cinsiyet

To my beloved husband Serhat CELEP
&
My wonderful family

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LIST OF ABBREVIATIONS

ANCOVA	: Analysis of Covariance
ADI	: Argument-Driven Inquiry
ASTA	: Argumentativeness Scale toward argumentation
ASTC	: Attitude Scale toward Chemistry
CG	: Control Group
df	: Degrees of Freedom
EG	: Experimental Group
GCT	: Gases Concept Test
GCT-I	: Gases Concept Test-I
GCT-II	: Gases Concept Test-II
I	: Interviewee
MANCOVA	: Multivariate Analysis of Covariance
MANOVA	: Multivariate Analysis of Variance
N	: Sample Size
PreGCT	: Pre- Gases Concept Test
PreASTC	: Pre- Attitude Scale toward Chemistry
PreASTA	: Pre- Argumentativeness Scale toward Agumentation
PostGCT	: Post- Gases Concept Test
PostASTC	: Post- Attitude Scale toward Chemistry
PostASTA	: Post- Argumentativeness Scale toward Argumentation
R	: Researcher
SD	: Standard Deviation
Sig	: Significance
SPSS	: Statistical Package for the Social Sciences Program
TCI	: Traditional Chemistry Instruction

CHAPTER 1

INTRODUCTION

Over the past few decades, science education has changed through seeing science learning as construction and evaluation of scientific knowledge (Eşkin & Bekiroğlu, 2009). These changes have suggested giving opportunities to students to take responsibility for their learning process by reasoning and reflecting metacognitively on their own learning (Duschl & Osborne, 2002). Hence, science learning is considered as construction and evaluation of scientific knowledge by using tools which includes generation of knowledge about the real world. According to Driver, Asoko, Leach, Mortimer and Scott (1994) learning science requires students' active participation through thinking, talking and writing by making sense of the scientific phenomenon, experiments and explanations. In order to meet this requirement in the learning context, the constructivist view of learning has emerged during the last two decades (Ernest, 1993). Therefore, science educators have focused on designing effective learning environments that student-centered inquiry practices into the classroom (Simon, Erduran, & Osborne, 2006). More inquiry based instructions have been suggested by the recent educational reforms in science classes (NRC, 2005; Walker, Sampson, & Zimmerman, 2011). In brief, constructivist learning strategies suggest to use inquiry based activities because inquiry based activities improve students' problem solving skills, critical thinking and understanding of concepts in learning science (Chiappetta & Adams, 2004). Further, inquiry could be embedded in various instructional methods such as learning cycle or conceptual change (Keys& Bryan, 2000).

The new educational trend in the nature of classroom environment emphasizes the construction of new knowledge on existing knowledge (Coştu, Ayaş, & Niaz, 2010).

When the students construct their own concepts, their constructions about a concept or their pre-existing knowledge sometimes could not be consisted with the conceptions that are scientifically accepted. These ideas are named as misconceptions (Nakhleh, 1992), alternative conceptions (Niaz, 2001; Palmer, 2001; Taber, 2001), naive beliefs (Pulmones, 2010; Schommer, 1990), children's ideas (Osborne & Wittrock, 1983), and preconceptions (Driver & Easley, 1978 as cited in Nakhleh, 1992). These alternative conceptions have various sources such as students' real life experiences, culture, and lack of knowledge from previous lessons or courses, and language (Nakhleh, 1992). One of the reasons of existence of alternative conceptions held by students is abstract nature of the concepts. Chemistry is one of the subjects that students have difficulties since the difficulty in understanding of meaning macroscopic and microscopic representation notions (Novick & Nussbaum, 1978). In this study, gases concept were examined which is an important topics of chemistry since the students have various alternative conceptions and learning difficulties on the topic (Azizoğlu, 2004; Çetin,2009; Lin, Cheng & Lawrenz, 2000; Niaz, 2000). One of the main reasons of students' alternative conceptions about "gases" topic is difficulty that students had visualization of particulate nature of matter since the invisibility of gas particles and make connections between these understanding with macroscopic level (Çetin, 2009). Since the "particulate nature of matter" also includes the kinetic theory of particles, it is also important to learn this subject to gain fundamental concepts of chemistry about atomic structure, chemical reactions, and chemical equilibrium (Harrison & Tregaust, 2002).

In order to prevent students' alternative conceptions, constructivist learning strategies have been recommended for conceptual understanding and conceptual change. Various studies have been emerged such as cooperative learning, conceptual change, learning cycle and inquiry, and Science Writing Heuristic approach (Keys, Hand, Prain, & Collins, 1999). These teaching methods are designed to create new classroom environment by taking students' existing conceptions or alternative conceptions into account that will help students to promote the understanding of scientific explanations. Besides these instructional models, most of the studies emphasized the importance of scientific argumentation for the acquisition of scientific knowledge in science education (Driver et al., 1994; Dushcl & Osborne, 2002; Mason, 1996). These studies emphasize that scientific argumentation plays an important role in science learning and it should be supported and promoted in learning environments (Jiménez-Aleixandre, Rodríguez, & Duschl, 2000; Kelly, Druker & Chen, 1998). In addition, scientific argumentation has a similar manner with social constructivist theories that seems learning as a social process. According to these theories learning occurs through social activities by interacting with other people and people internalize these processes and can use them independently (Schunk, 2008). So, applications of the social constructivist theories in instructions involve social interaction among peers and a guided teacher likewise scientific argumentation process.

In this study, a new instructional model, Argument-Driven Inquiry (ADI) instructional model was used as the combination of scientific argumentation and inquiry (Walker, Sampson, Grooms, Zimmerman, & Anderson, 2012; Walker, Sampson, & Zimmerman, 2011). The ADI instructional model is a laboratory based model that includes inquiry and exploration in science education that contribute the importance of argumentation in science (Osborne, Simon, Christodoulou, Howell-Richardson, & Richardson, 2012; Walker et al., 2012). This model provides a wide range perspective by combining argumentation in laboratory based instruction (Walker & Sampson, 2013). The roots of ADI instructional model comes from social constructivist theories because it promotes critical thinking and reasoning skills by the inquiry based laboratory activities through collaborative group work (Walker & Sampson, 2013). This instructional model provides students an opportunity to develop a scientific method in order to collect data, design and conduct an investigation and use data to find an answer for researchable question though the process of learning concepts with inquiry, argumentation, and writing in science and peer review (Sampson, Grooms, & Walker, 2011).The ADI process was defined as follows (Sampson, Grooms, & Walker, 2009; Walker et al., 2011):

1) The identification of the task or a research question

2) The generation of data through systematic observation or experimentation

3) The production of tentative arguments

4) Argumentation session

5) The creation of a written investigation report

6) Double-blind peer-review

7) Revision of the report based on the peer review

The implementation of ADI starts with a major topic to be investigated by students. Instructor gives a researchable question which is needed to answer. The students work with collaborative group to develop an investigation method in order to answer question provided by instructor (Walker et al., 2011). During investigation, procedure being followed by students is uncertain. Because the uncertain nature of procedure, students are taught to carry out an investigation to reach knowledge. In other words students are expected to understand the way of scientist follow by doing science through designing method, interpreting empirical data and evaluating new explanations (Sampson & Grooms, 2008).

Although ADI was originated in undergraduate students, the uses of it have been spread out many different grades. The implementation of ADI in undergraduate began to in the 2009 (Walker et al., 2012). In middle and high schools, there is also a growing interest in ADI; however few researches conducted on the use of ADI in high school classrooms (Sampson, Enderlee, Grooms & Witte, 2013; Sampson et al., 2014a, 2014b). So the researcher decided to conduct research on high school students. The adaptation of ADI in high school chemistry laboratories looks like valuable to enrich the lack of research in these areas.

Besides the cognitive variables, measuring affective variables is very important in the context of education. In science education, as well as teaching strategies taking students' attitude towards science into account is also essential in order to improve the quality when learning science (Koballa & Glynn, 2007). A growing body of research on attitude in science offers moderate correlation between students' achievement and attitudes towards science (Weinburgh, 1995; Simpson & Oliver, 1990; Osborne& Collins, 2000). The relationship between attitude and achievement is affected from various factors such as gender, early childhood experiences, and the nature of classroom (Pintrich, Marx, & Boyle, 1993; Osborne, Simon, & Collins, 2003). On the other hand, attitude towards science in other words interest in science can be improved by effective teaching methods, curriculum or the supportive classroom environment (Walker, Sampson, & Zimmerman, 2011). One of the focuses of this study was to examine the relationship between students' attitudes toward chemistry and method used to during study.

From the point of the researcher, the purpose of this study was specified as;

To seek whether there is a significant impact of Argument-Driven Inquiry (ADI) instructional model when compared to traditional chemistry instruction on 10th grade high school students' conceptual understanding in the gases concepts.

To seek whether there is a significant impact of Argument-Driven Inquiry (ADI) instructional model when compared to traditional chemistry instruction on 10th grade high school students' attitude toward chemistry.

1.1 Main Problems

The main problem of the study is that:

1. What is the effect of Argument-Driven Inquiry(ADI) instructional model and gender on 10th grade students' understanding in the gases concepts and their attitude toward chemistry when compared to traditional chemistry instruction at public high schools in Yenimahalle district of Ankara?

1.2 Sub-Problems

1. What is the main effect of treatment (Argument-Driven Inquiry instructional model (ADI) and traditional chemistry instruction (TCI)) on the population mean of collective dependent variables of 10th grade students' posttest scores of understanding of gases concepts and their attitude toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled?

2. What is the main effect of gender on the population mean of collective dependent variables of 10th grade students' posttest scores of understanding

of gases concepts and their attitude toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled?

3. What is the effect of interaction between treatment (Argument-Driven Inquiry instructional model (ADI) and traditional chemistry instruction (TCI)) and gender on the population mean of collective dependent variables of 10th grade students' posttest scores of understanding of gases concepts and their attitude toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled?

4. Is there a statistically significant mean difference between the effects of Argument-Driven Inquiry instructional model (ADI) and traditional chemistry instruction (TCI) on students' posttest scores of understanding of gases concepts when the effects of attitude toward chemistry pre-test scores are controlled?

5. Is there a statistically significant mean difference between males and females in students' posttest scores of understanding of gases concepts when the effects of attitude toward chemistry pre-test scores are controlled?

6. What is the effect of interaction between gender and treatment with respect to students' posttest scores of understanding of gases concepts when the effects of attitude toward chemistry pre-test scores are controlled?

7. Is there a statistically significant mean difference between the effects of Argument-Driven Inquiry instructional model (ADI) and traditional chemistry instruction (TCI) on students' posttest scores of attitudes toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled?

8. Is there a statistically significant mean difference between males and females with respect to students' posttest scores of attitudes toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled?

9. What is the effect of interaction between gender and treatment with respect to students' posttest scores of attitude toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled?

10. Is there a statistically significant mean difference between the post-test scores and pre-test scores of students taught by Argument-Driven Inquiry instructional model (ADI) on the population means of tendency of argumentation?

1.3 The Null Hypotheses

The problems listed above were checked with the hypotheses given below:

H_o1: There is no statistically significant main effect of treatment (Argument-Driven Inquiry instructional model (ADI) and traditional chemistry instruction (TCI)) on the population mean of collective dependent variables of 10th grade students' posttest scores of understanding of gases concepts and their attitude toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled.

H_o2: There is no statistically significant main effect of gender on the population mean of collective dependent variables of 10th grade students' posttest scores of understanding of gases concepts and their attitude toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled.

H_o3: There is no statistically significant effect of interaction between treatment (Argument-Driven Inquiry instructional model (ADI) and traditional chemistry instruction (TCI)) and gender on the population mean of collective dependent variables of 10th grade students' posttest scores of understanding of gases concepts and their attitude toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled.

H_o4: There is no statistically significant mean difference between the effects of Argument-Driven Inquiry instructional model (ADI) and traditional chemistry instruction (TCI) on students' posttest scores of understanding of gases concepts when the effects of attitude toward chemistry pre-test scores are controlled.

H_o5: There is no statistically significant mean difference between males and females in students' posttest scores of understanding of gases concepts when the effects of attitude toward chemistry pre-test scores are controlled.

H_o6: There is no statistically significant effect of interaction between gender and treatment with respect to students' posttest scores of understanding of gases concepts when the effects of attitude toward chemistry pre-test scores are controlled.

H_o7: There is no statistically significant mean difference between the effects of Argument-Driven Inquiry instructional model (ADI) and traditional chemistry instruction (TCI) on students' posttest scores of attitudes toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled.

H_o8: There is no statistically significant mean difference between males and females with respect to students' posttest scores of attitudes toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled

H_o9: There is no statistically significant effect of interaction between gender and treatment with respect to students' posttest scores of attitude toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled.

Ho10: There is no statistically significant mean difference between the post-test scores and pre-test scores of students taught by Argument-Driven Inquiry instructional model (ADI) on the population means of tendency of argumentation.

1.4 Definitions of Important Terms

Main terms used in this study are described as following:

Scientific Argumentation: Scientific argumentation is a student- centered method in which students make explanations, provide evidence, evaluate validity of explanations with appropriate reasoning and consider different perspectives in order to understand scientific phenomena (Nussbaum, Sinatra & Poliquin, 2008). Teachers' role is facilitator or a coach in teaching-learning process and avoids directly transfer knowledge to students. Students try to construct an argument by group or individually.

Argument- Driven Inquiry: Argument-Driven Inquiry is a scientific argumentation model which includes inquiry based instruction during experimentation process. It has seven steps in which students engage in collecting and analyzing data and testing their explanations, generating their own arguments, and sharing their findings with others as a social aspect of argumentation (Walker, 2011).

Traditional Instruction: It is a teacher-centered instruction in which teacher tries to transfer knowledge directly to students. Students are passive in this instruction. After making explanations about the current concepts, the teacher solves end-of-chapter problems about the current topic.

Alternative conceptions: Any concept which is different from the commonly accepted scientific meaning of the term.

Attitude toward Chemistry: Attitude is defined by Osborne et al.(2003) as, "The feelings, beliefs and values held about an object that may be the enterprise of science, school science, and the impact of science on society or scientists themselves" (p.1053).

1.5 Significance of the Study

Science learning is considered as generation and evaluation of scientific knowledge by using tools about the real world. At this point, argumentation serves as a critical tool in the growth of scientific knowledge as a form scientific discourse. Over the last decade researchers take promoting argumentation into account in science classrooms and support students to take responsibility in order to evaluate the process and products of inquiry (Driver, Newton, & Osborne, 2000; Duschl & Osborne, 2002). However, students have few opportunities to engage in argumentation in the science context and it is still ambiguous how to integrate and support argumentation in science classrooms for teachers (Newton, Driver, & Osborne, 1999; Simon, Erduran, & Osborne, 2006). Therefore, this study is important in terms of attempt to design an inquiry-based scientific argumentation model which is called Argument-Driven Inquiry (ADI), and examine whether there is a significant effect of Argument-Driven Inquiry (ADI) instructional model on students' conceptual understanding in chemistry. This present study provides a new perspective to integrate the combination of scientific argumentation and inquiry into chemistry classrooms by explaining implementation of ADI instructional model in more detail.

ADI instructional model also provides to students a laboratory experiences which promotes inquiry and improve students' understanding of the scientific content. The students are given an opportunity to conduct an investigation method that designed by them in order to produce data or to test the questions. The instructional method also helps teachers to design laboratory activities to change the nature of a traditional laboratory instruction (Sampson, Groom, & Walker, 2010). On the contrary of traditional laboratory courses which are designed as a "cookbook" that involves a step-by-step procedure for analyzing the data, well designed ADI instructional model supports meaningful learning for students during the development of an argument process as a product of scientific inquiry (Sampson et al., 2013). Hence, this current study is important in terms of providing well designed laboratory experiences which promotes inquiry and generating scientific argumentation to improve development of conceptual understanding of students in chemistry.

In addition to development of students' conceptual understanding, ADI instructional model also improves students' attitudes toward science positively (Walker et al., 2012). The main emphasis of this study, not only was to promote scientific understanding of students but also improve of students' attitudes toward chemistry.

Students' attitudes are also associated with their achievement and the development of positive attitudes toward chemistry could motivate students to learn chemistry (Osborne et al., 2003). In this study, since the students who have more positive attitudes are more willing to involve in class activities, activities which are designed to facilitate meaningful learning were also aimed to develop more positive attitudes towards chemistry.

Although there are many studies in order to promote and support scientific argumentation in teaching and learning with inquiry (Bybee, Trowbridge, & Powell, 2004; Carin, Bass, & Contant, 2005; Cavagnetto, 2010; Clark & Sampson, 2007; Eisenkraft, 2003; Erduran, Simon, & Osborne, 2004; Kıngır, Geban, & Günel, 2012; Marek & Cavallo, 1997; Sampson & Gleim, 2009; Sampson, Grooms, & Walker, 2009; Simon et al., 2006; Simonneaux, 2001; Walker & Zeidler, 2007), this study has many contributions. In the literature, there are few studies combining argumentation and inquiry to facilitate learning chemistry on high school students (Kıngır et al., 2012; Sampson et al., 2013; Sampson et al., 2014a; Sampson et al., 2014b). In addition, the studies, in which ADI method followed, mostly focused on undergraduate students. This study also makes contributions to implementation of ADI instructional model in high school chemistry with the extensive sample consisted of 157 students. The researcher did not encounter any study about the implementation of ADI instructional model in Turkish chemistry education. Therefore, outcomes of this study can contribute to Turkish chemistry education by presenting the ADI instructional model.

The purpose of the study is to evaluate the effect of ADI instructional model on students' conceptual understanding and attitudes towards chemistry, and to draw conclusion based on the evidence for students' conceptual understandings of gases concepts and attitude toward chemistry between the experimental and traditional groups. In the light of this purpose, this study is expected to contribute to chemistry education with regard to develop a conceptual understanding and promote students' attitudes toward chemistry.

CHAPTER 2

REVIEW OF THE RELATED LITERATURE

This chapter includes the information about alternative conceptions, alternative conceptions in gases, constructivism, and argumentation, argumentation in science, Argument-Driven Inquiry instructional model and attitude.

2.1 Alternative conceptions

In recent years, many of the research studies showed that students have difficulties about science concepts (Gilbert & Watss, 1983). Hence science education researchers have started to discuss the importance of these difficulties in learning process nearly at the beginning of 70's (Treagust, Duit, & Fraser, 1996; Driver, 1989). As a result of these difficulties, students tend to hold incorrect conceptions about science that they come to science class with them. In brief, students come to class with their own ideas, experiences, concepts and beliefs that may affect their further learning (Chandrasegaran, Treagust, & Mocerino, 2007; Coştu, Ayaş & Niaz, 2010; Garnet, Garnet, & Hackling, 1995). Some of these ideas and explanations that students had are different from the views of scientists. Hence, it is crucial to know students come to class what prior knowledge in order to help them construct new knowledge (Tsai, 2000a, 2000b). When the students construct their own concepts, their constructions about a concept or their pre-existing knowledge sometimes could be not consisted with scientifically accepted conceptions. These ideas are named as misconceptions (Griffiths & Preston, 1992; Nakhleh, 1992), alternative conceptions (Niaz, 2001; Palmer, 2001; Taber, 2001), alternative frameworks (Driver & Easley, 1978 as cited in Nakhleh, 1992) naive beliefs (Pulmones, 2010; Schommer, 1990), children's ideas (Osborne & Wittrock, 1983), and preconceptions (Driver & Easley, 1978 as cited in Nakhleh, 1992). In this current study, the alternative conception term that means students' inconsistent conceptions with the commonly accepted scientific conceptions was used.

These alternative conceptions have various sources such as students' real life experiences, culture, and lack of knowledge from previous lessons or courses, instruction, and language (Nakhleh, 1992; Duit & Treagust, 1995). According to Fisher (1985) alternative conceptions meet the learners' needs and resource of these misleadings can be strong word association, confusion, conflict or lack of knowledge. Taber (2001) claimed that most of the alternative conceptions in chemistry resulted from the school experiences. According to Taber (2001), students' alternative conceptions in chemistry came from formal learning environment such as students' alternative conceptions in previous science lessons, and misleading terminologies in the used language.

Further, alternate conceptions have some characteristics as follows;

- Alternate conceptions are in conflict with scientifically accepted ones (Çetin, 2009)
- Alternative conceptions tend to be shared by many different individuals.
- Sometimes alternative conceptions have their roots in historical background and are passed on from one generation to another (Blosser, 1987).

In order to diagnose students' alternative conceptions on a specific topic, many different methods used such as interviews (Bell, 1995; Thompson & Logue, 2006), concept maps (Tsai & Chou, 2002), open-ended questions(Çalık & Ayaş, 2005) and multiple-choice questions (Halloun & Hestenes, 1985, Tamir, 1971 as cited in Tregaust, 1986). All of these methods both have some advantages and disadvantages. While multiple choice tests have advantage over interviews in terms of being applied great number of students in short time and easy assessment, interviews are superior to multiple choice tests in terms of providing deeply investigation of students' answer (Peşman, 2005). To overcome limitations of these methods two-tier multiple choice diagnostic test was suggested by Treagust to diagnose students 'alternative conceptions (Treagust, 1986, 1995).

In a diagnostic two tier test; the first tier represents an ordinary multiple choice question and second tier includes the reason for the answer of first tier in multiple-choice format (Tan, Goh, Chia, & Treagust, 2002; Treagust & Chandrasegaran, 2007). The incorrect reasons in second tier include students' alternate conceptions related to a specific content area gathered from literature, interviews, or open-ended questions. In the literature a considerable amount of diagnostic test have been developed by researchers and have been used for diagnose alternate conceptions in chemistry (Chou & Chiu, 2004; Coştu et al.,2007; Kırbulut, Geban, & Beeth, 2010; Odom & Barrow, 1995; Tan & Treagust, 1999; Treagust, 2006; Wang, 2004).

The use of diagnostic two-tier test not only provides to identify students' alternative conceptions but also probes the reasons behind the explanations of students (Tsai & Chou, 2002). Moreover, a two-tier test has the ability to administer a great number of students and allow teachers to analyze answers of students objectively. Therefore, two tier tests have been used for diagnostic assessment in the literature for a long time (Tsai & Chou,2002).

Chemistry is also one of the subjects that students have difficulties since the difficulty in understanding of meaning macroscopic and microscopic representation notions (Novick & Nussbaum, 1978). In chemistry, one of the reasons of alternate conceptions held by students is abstract nature of the concepts. Studies have revealed that students hold many misconceptions on a variety of topics in chemistry such as chemical equilibrium (Bilgin & Geban, 2006; Canpolat, Pınarbaşı & Sözbilir, 2006; Demirci, Yıldıran & Geban, 2012; Özdemir, Geban, & Uzuntiryaki, 2000; Özmen, 2007; Thomas & Schwenz, 1998; Voska & Heikkinen, 2000); electrochemistry (Karslı & Çalık, 2012; Sanger & Greenbowe, 1999; Yürük, 2007) phase equilibrium (Azizoğlu, Alkan & Geban, 2006) , particulate nature of matter (Ayaş, Özmen & Çalık, 2010; Bektaş, 2011; Griffiths & Preston, 1992; Horton, 2001) chemical bonding (Birk & Kurtz, 1999; Özmen, Demircioglu, & Demircioglu, 2009; Pabuçcu & Geban, 2012; Taber, 2003; Tan & Treagust, 1999); acids-bases (Cros, Chastrette & Fayol, 1988; Çakır, Uzuntiryaki & Geban, 2002; Çetin-Dindar, 2012; Demircioğlu, Ayaş & Demircioğlu, 2005; Hand & Treagust, 1988; Ross & Munby, 1991; Schmidt, 1997; Sheppard, 1997), rate of reaction (Çakmakçı, 2010; Çakmakçı, Leach & Donnelly, 2006; Çalik, Kolomuç, & Karagölge, 2010), thermochemistry (Beall, 1994; Boo, 1998; Greenbowe & Meltzer, 2003), ionization energy (Tan et al., 2006), chemical and physical change (Andersson, 1986; Kıngır, 2011; Yeğnidemir, 2000) and gases (e.g. Aslan & Demircioğlu, 2014; Hwang, 1995; Hwang &Chiu , 2004; Mas, Perez, & Harris, 1987; Mayer, 2011; Niaz, 2000; Novick & Nussbaum, 1978; Stavy, 1990).

In this study, gases concepts were examined which is an abstract and important topics of chemistry since the students have various alternative conceptions and learning difficulties on "gases" topic (Azizoğlu, 2004; Çetin, 2009; Niaz, 2000; Stavy, 1990).

2.2 Alternative conceptions in Gases

According to Johnstone (1993), chemistry can be taught at three levels namely, macroscopic level, microscopic level, and symbolic level. Since the gases concepts are required to understand the "microscopic level of matter", students had great deal of difficulty learning gas concepts (Stavy, 1990). One of the main reasons of students' alternative conceptions about gases topic is difficulty that students had visualization of "particulate nature of matter" and make connections between these understanding with macroscopic level (Çetin, 2009). Besides, it was concluded that understanding chemistry at the submicroscopic level which refers particulate level may reduce alternative conceptions in this area (Garnet et al., 1995).

Since the "particulate nature of matter" also includes the kinetic theory of particles, it is also important to learn this subject to gain fundamental concepts of chemistry about atomic structure, chemical reactions, and chemical equilibrium (Harrison & Tregaust, 2002). In brief, "particulate nature of matter" serves as a keystone in the development of the other some basic chemistry concepts (Johnson, 2005).

There are various studies with regard to examine students' difficulties and alternative conceptions in gases concepts. These studies are in the scope of determining and eliminating students' alternative conceptions at different grades, investigating the relationship between students' understanding of concepts and alternative conceptions, examining the teachers' and pre-service teachers' alternative conceptions, and investigating the effectiveness of different teaching methods to eliminate the alternative conceptions. These studies conducted in worldwide are reviewed in detail.

Novick and Nussbaum (1978) conducted a study with 14 years old students for exploring students' conceptual understanding of the particulate nature of matter. In the study, they asked students to draw chemical drawings, open-ended questions and multiple-choice questions from given explanations or drawings. Their findings revealed that students hold some alternative conceptions about gases, such as gas is composed of invisible particles, gas particles are not evenly scattered in a closed system, there are more particles (air, dirt etc.) between gas particles, when a gas is composed, particles aggregate at the bottom. The researchers also documented that when students were asked to draw representation of particles in air, they used all the spaces in between the particles in their drawing since they thought matter as continuous. After a few years same researchers made a study about properties of gas particles with at different age levels. The researchers found that, students had similar difficulties about the idea of empty space between particles and motion of particles as intrinsic even they were at high school or college (Novick & Nussbaum 1981).

Séré (1986) searched for 11 year olds students' ideas about gases before the implementation of topic. The findings of her study showed that alternate conceptions of students associate with function of objects, like footballs, tires etc. For example, students thought that; "hot air rises", or "air always wants to expand everywhere". Since the use of daily language causes the arousing of these alternative conceptions (as cited in Barker, 2000).

Stavy (1990) made a study with children at different ages (9-15) and examined the children's understanding of changes in the state of matter and reversibility of this process. In her study, she presented the change of state from liquid to invisible gas in a closed container and from solid to visible gas. Then, students were interviewed and they were asked about the conservation of matter, conservation of properties of matter, conservation of weight and reversibility of this process. She found that many students believed that the gases state of matter is lighter than other forms of matter, and unfortunately around 30% of the students even assumed that gases had no weight. In her earlier work, she also suggested that, even if children learn intuitively about solids and liquids, since the some gases were invisible children did not form nay concept about gases spontaneously. In brief, students do not understand the concrete idea of the "particulate nature of matter", so they cannot understand the microscopic level of matter and such as gases. The researcher also reported that students may make a wrong comparison between the macroscopic and microscopic levels of matter since the experiences in daily life.

Another similar study was conducted by Driver et al., (1994) about conservation of mass related with gases with students aged from 9 to 13. The findings of this study showed that students not only fail to understand conservation of mass but also some students have developed a "negative weight" conception of gases. Researchers emphasized that these ideas come from students' daily life experiences about gases for instance; when balloons filled with helium float, they thought it is lighter or "to weigh less".

Hwang (1995) examined the middle, high school, and college students' conceptions of gas volume with 1029 students in Taiwan. According to this extensive study results students hold some alternative conceptions about gases, such as volume of a gas is the size of the particles, and gases have no volume. It was also revealed that, although middle, high school, and college students have similar misconceptions, when students' grade level increased their alternative conceptions decreased.

Niaz (2000) examined the relationship between freshman students' performance on understanding of gases in the history of science. He asked a question that not requires any calculations as algorithmic problem but rather conceptual understanding about gases. The findings of study illustrated that students' performance was quite low since the problem required microscopic explanations. He also concluded that some of the students' alternative conceptions such as, attractive forces between gas molecules increases by way of the temperature decreases were resistant to change. This study also showed that solving simple algorithmic problems do not show a success on microscopic level of science. Moreover, students held ideas that aroused with the drawings about the distribution of gas particles were surprisingly similar with those scientist held until about 1860.

In a similar manner, Azizoğlu (2004) investigate tenth grade students' alternative conceptions about gases concepts in Turkey. One hundred tenth grade students were enrolled in the study and a concept test which includes 40 multiple-choice questions was applied. The results of study revealed that students hold many alternative conceptions about conceptions of gases that parallel with the literature.

Hwang and Chiu (2004) conducted a study in grade 5-8 in Taiwan and explored students' ideas about gases. Two alternative conceptions were addressed, which were gas was not distributed homogeneously in the whole container, and is dependent on the position of the bottle and two gases homogeneously mixed but not distributed in the whole space. It was claimed that these alternative conceptions emerged from ambiguous terminology of particulate theory.

The study conducted by Şenocak, Taşkesengil and Sözbilir (2007) examined the effectiveness of Problem-Based Learning on pre-service teachers learning of gases concepts. They used quasi-experimental method and administered a diagnostic test that composed of 22 multiple choice questions as pre and posttest in order to determine pre-service teachers' alternative conceptions. At the end of the study, researchers found that pre-service teachers have alternative conceptions however; experimental group students had less alternative conceptions than those of control group.

In another study, Chiu (2007) emphasized that secondary school students thought about the behavior of gas particles instinctively. The students tend to use their real life experiences in order to interpret particles behaviors in the submicroscopic level. For instance, they thought that gas particles are lighter the other forms of matter and they always float top of the container like lighter objects that could be observe with naked eyes in the external life.

Mayer (2011) conducted a study with 63 students from three different high school chemistry classes. The researcher used pre-posttest design about gases and gas laws in order to identify students' major misconceptions and administered a concept test with seven questions. The findings of pretest showed that 86% of the students believed gases weighted less than solid and 92% of students thought that water would decompose when evaporated. After pretest, researcher used a macroscopic demonstration about water boiling and conducted an investigation about mass of gas. After treatment, same test was used as posttest and results of posttest showed that 46% of the students correctly answered the mass of the gas iodine would remain same. Besides, 48% percent of the students showed water vapor in a particulate level correctly, but 52% of the students kept hold the misconception about decomposition of water when evaporated. Moreover, researcher revealed that one surprising result of the study was that percentages of students who thought the iron nail rust would weigh the same as an iron nail increased while the percentages of students who thoughts rust weighs more, decreased. It was concluded that students ignored microscopic level of particles or atoms, rather they only incorrectly applied the concepts argued in class.

Moreover, Liang, Chou and Chiu (2011) searched for students' ideas about behavior of gases with a six two-tier items in a diagnostic instrument and also examined teachers' prediction about students' test performance. The participants of the study were 102 eighth graders, 92 ninth graders, and 31physical science teachers in junior high schools in Taiwan. The findings of study illustrated that only some of students could answer the all of the questions correctly, and when students' grade level increased their alternative conceptions decreased. In addition, they found that if orientation of the container changed, students also changed their thoughts about gas behavior. It was concluded that students had not a consistent model to answer set of six questions. Further, students have more difficulty especially questions about change of gas pressure and teachers failed to guess correctly the students' understanding of the behavior of gas particles since the pressure concept.

Aydeniz, Pabuçcu, Çetin and Kaya (2012) made a study with 108 high school students. They used quasi-experimental method and administered a diagnostic test and collected data pre- and post-tests. They found that students hold many misconceptions about behavior of gases. The results of study also showed that students in the experimental group held fewer alternative conceptions after the intervention than students in the control group. Although experimental group students abandoned many of their alternative conceptions between pre- and post-test, the number of students who had alternative conception about the relationship between the temperature, volume and pressure of a gas in a closed container increased from 10 students to 14 students. On the other hand 15 students from the control group also held the same alternative conception on the post-test. Many alternative conceptions were addressed, which were temperature is a required value for calculating a gas' partial pressure; when the air is compressed all the air particles are pushed to the end of syringe; heavy gases occupy more space than the lighter ones and gas particles expand as the temperature. At the end of the research researchers also claimed that 80 % of the experimental group students and about 50% of the control group students changed their primary ideas on all of the 17 alternative conceptions about behavior of gases.

In another study, Aslan and Demircioğlu (2014) investigated the effect of video-assisted conceptual change texts on 41, 12th grade students' understanding and alternative conceptions concerning the gas concept. They used a non-equivalent pretest-posttest control group design with a true-false test which is consisted of 29 statements. At the end of the study, researcher found that although experimental group students take treatment, many of students have still continued to hold the alternative conceptions about gas concepts. For example, before the treatment, 84% of students in experimental group and 68% of students in control group hold an alternative conception that "Gases are hotter than liquids in the same setting". After the treatment, when 11% of the experimental group students continued to hold this alternative conception, 41% percentage of control group students continued to hold it. The researchers reported those alternative conceptions are resistant to change and it is not easy to eliminate them.

Demircioğlu and Yadigaroğlu (2013) conducted a study with 107 pre-service chemistry teachers, 141 pre-service science teachers and 40 high school students in order to compare the understanding levels and alternative conceptions of high school students and student teachers concerning the gas concept. They used a cross-sectional and collected data a concept test about gases containing 16 questions, 10 of questions are multiple-choice and 5 are two-tier questions and one question requiring drawing was used. The results illustrated that the participants in all groups have a many alternative conceptions. In addition, pre-service chemistry and science teachers have similar alternative conceptions with high school students. For example, when they were asked the distribution of gas particles in different temperatures in question 16, many of the participants from each group have same alternative conception at -5 °C "particles stick to wall of the container" and showed a representation in which gas particles accumulated at 80 °C.

2.3 Constructivism

Constructivism is a theory of learning which emphasizes that individuals construct their own understandings or knowledge when they attempt to make sense of their experiences through the interaction of existing understandings and immediate learning environment (Cannella & Reiff, 1994, Richardson, 1997 as cited in Liu & Matthews, 2005).

Constructivism is interested in how one constructs his knowledge from his experiences, beliefs and mental structures which are used to interpret objects and events. According to constructivist view there is no single reality and our world is shaped by our mind by interpreting events, objects, and perceptions on the real world and our interpretations are personal. So we conceive of the external world in terms of our individual experiences.

The roots of constructivism in psychology and philosophy came from Jean Piaget, Jerome Bruner, Lev Vygoysky, John Dewey, Nelson Goodman, Immanuel Kant and von Glaserfield. Although those pioneers were shaped the early constructivism, they contributed the different parts of the constructivist theory. For instance, when Piaget emphasizes the importance of cognitive development with active mental processing on the part of learner as a pioneer of cognitive constructivist, Bruner and Vygotsky are the contributors of the social constructivism that gave importance of social interaction by acquiring knowledge. von Glaserfield is also known as the pioneer of radical constructivism which claims construction of mental structures and personal meaning (Driscoll, 2005; Gredler, 2001).

All of those constructivist theories substantially stated that, learners are active when they construct knowledge and improve understandings about the world. Moreover, constructivism not only emphasizes the constructive process, but also emphasizes to be aware and control the construction process (Tsai, 2000b). More specifically, social constructivism defines learning as a social process that begins with social interaction with other people or environment and then knowledge is constructed individually. Vygotksky seems social interaction as only way of learning and claims that children learn in a social interaction in a social environment. Vygotksy's theory also emphasizes that every higher mental function was interpersonal or social before, and then it became an intrapersonal mental function. Learners bring their own mental structure to social interaction environment and construct meanings with their experiences (Schunk, 2008). Moreover, Bandura's Social-Cognitive Theory also emphasizes the importance of observation and collaboration in learning. So, applications of the social constructivist theories in instructions involve social interaction among peers and a guided teacher. There are many educational applications of social constructivist theories such as instructional scaffolding, reciprocal teaching, peer collaboration, cooperative learning, problem-based instruction, class discussion and apprenticeship are some of these applications (Schunk, 2008). Peer collaboration is the notion of collective activity. When peers come together to accomplish a task cooperatively, this social interaction can lead learning. If each student has assigned the responsibility, researches showed that cooperative work is most effective (Schunk, 2008). It is clear that, many teachers are still using applications of social constructivist theories such as group works, class discussion or guided discovery consciously or unconsciously.

In a constructivist manner, evaluating how learners construct knowledge is more important than results of learning product (Duffy & Jonassen, 1992). So, when students are acquiring knowledge, teachers encourage students to inquire, active participation by thinking, talking and writing in learning process, and help to build upon students' interests and prior experiences. Moreover, both student and teacher may evaluate how the students are progressing. According to Driver et al. (1994), learning science requires students' active participation by thinking, talking and writing by interpreting and evaluating the scientific phenomenon, experiments and explanations. Moreover, from the perspective of constructivist theories, construction of knowledge related to the interaction with environment also involves to engage critical thinking and problem solving skills (Driver et al., 1994).

Since the constructivist view of learning in science classrooms leads to students to gain and promote conceptual understanding about science through active participation and develop an understanding of how scientific knowledge is constructed, providing constructivist learning environments became main concern of educators (Yalçın-Çelik et al., 2014). So, science educators have focused on designing effective learning environments that student-centered inquiry practices into the classroom (Simon, et al., 2002).

As a result of this development in the field, many instructional methods have been emerged though the implication of constructivist theories such as, learning cycle model (e.g. Cavallo, McNeely, & Marek, 2003, Bektas, 2011; Çetin-Dindar, 2012; Pabuçcu, 2008) conceptual change (e.g.Posner, Strike, Hewson, & Gertzog, 1982), argumentation (e.g. Clark & Sampson; 2009; Cross, Taasoobshirazzi, Hendricks, & Hickey, 2007; Demirci, 2008; Kaya, 2005; Niaz, Aguilera, Maza, & Liendo, 2002; Osborne, Erduran, & Simon, 2004; Walton, 1999) cooperative learning (e.g. Chiu,2004; Johnson & Johnson, 1992), concept mapping (e.g. Novak, 2002, Novak & Cañas, 2008; Uzuntiryaki & Geban, 2005;) etc.

Following these trends in the field of science education, scientific argumentation approach which is grounded in social constructivist theories that are based on the idea that learning begins with social interaction with other people or environment is used in this current study. Since the argumentation contributes the development of conceptual understandings and provides an understanding of how scientific knowledge is constructed (Duschl & Osborne, 2002; Jiménez-Aleixandre et al., 2000; Osborne, 2005). It is clear that scientific argumentation also involves social interaction among peers in learning context and also has similarities with social constructivist theories in terms of explaining learning from social context to individual context. Furthermore, scientific argumentation approaches has the potential of determine and eliminate of alternative conceptions (Baker, 1999) since argumentation has this potential thanks to its nature (Nussabaum & Sinetra, 2003). In other words, argumentation leads to conceptual change (Baker 1999; Jonassen &

Kim, 2010; Nussbaum & Sinatra 2003). When argumentation embedded in science learning environments, it helps to develop scientific understanding and also helps to improve scientific reasoning skills of students (Dusch & Osborne, 2002).Since one of the concerns of this study is to examine students' alternative conceptions, conceptual change approach is taken into consideration as an implication of constructivist theories.

2.4 Conceptual Change

Conceptual change approach comes from the idea of constructivism in science education (Hewson & Thorley, 1989).Conceptual change approach basically propounds the process that addressing alternative conceptions and exchanging these existing concepts with new appropriate science concepts (Dole & Sinatra, 1998; Liang & Gabel, 2005).

In the early 1980s, Posner, Strike, Hewson, & Gertzog (1982) propound a theory which was inspired by Kuhn's and Lakatos's ideas and Piaget's concepts of assimilation and accommodation. According to Piaget's theory which is based on constructivism knowledge is an individual construct. The major principle of instruction is to use methods that include prior knowledge and the techniques that cause assimilation and accommodation. When an individual faced with new concepts or experiences to integrate new conceptual matter with his existing schemata, assimilation occurs. It means that putting more concepts into existing schemata. If an individual can't assimilate a new conceptual matter existing schemata because there are no schemata which fits new conceptual matter, accommodation occurs and individual creates a new schemata or modifies his old one. It means that one changes his cognitive structure. Posner et al. (1982) suggested the conceptual change model based upon Piaget's key ideas. They stated that conceptual change has four cognitive conditions that must be fulfilled in order to achieve conceptual change: dissatisfaction, intelligible, plausible, and fruitfulness (Posner et al., 1982).

When learner met different conditions, if dissatisfaction occurs with existing conceptions conceptual change starts. A new conception must be intelligible for learners and they understand what it means. A new conception must be plausible and leaners perceive and believe their new conceptions to be true. Thus, new concept should be consistent with existing ideas. Lastly, a new conception must be fruitful and learner should find it useful. Beside, fruitful conception must cover a plausible and intelligible conception (Harrison & Treagust, 2001).

According to Posner et al. (1982) and Hewson and Thorley (1989), conceptual changes occur or not occur when the status of conceptions raise or lower. In brief, if status of the conception raises and so the learner understands, accepts, and find it useful. The first step of raising status is "intelligibility". If a new conception is intelligible, it becomes either "plausible" or "fruitful" for learner, and then its status will have risen and can be integrated with pre-existing concepts. However, if the new conception conflict with existing knowledge and is not intelligible for learner, it cannot be established till the status of the existing conception is lowered. Moreover, learner's "conceptual ecology" have a vital role in order to determine the status of a conception because, it provides the conditions in terms of which the learner decides whether the new conception is intelligible, plausible and fruitful. In other words, the learner's conceptual ecology has an importance in terms of selection of a new concept to be learned (Hewson & Hewson, 1983).

In science education, conceptual change learning strategies has emerged in the 1980s. As mentioned before, the roots of conceptual change come from the foundations of constructivist learning strategies and this approach can be thought as an implication of constructivist theories. According to conceptual change, knowledge is personally and socially constructed and learners have responsibility for their learning process by reasoning and reflecting metacognitively on their own learning (Duschl & Osborne, 2002). The main aim of these conceptual change strategies is also promoting students 'conceptual understanding of science (Duit & Treagust, 2003). Moreover, conceptual change is one of the strongest theories in order to diagnose and eliminate students' alternative conceptions. Conceptual change strategies in science education, take students' existing conceptions or alternative conceptions into account that will help students to promote the understanding of scientific explanations. Posner et al. (1982) claimed that "teachers can spend a substantial portion of their time diagnosing errors in thinking and identifying defensive moves used by students to resist accommodation" (p. 226). Therefore, creating an environment for dissatisfaction with students' alternative conceptions is teachers' responsibility for conceptual change. With the emergence of conceptual change in the science area, many of teaching strategies were used as the implication of conceptual change approach such as conceptual change texts (Chambers & Andre, 1997), 5E learning model (Akar, 2005), analogies (e.g. Şeker, 2006),concept mapping (e.g. Uzuntiryaki &Geban, 2005; Yılmazoğlu, 2004), argumentation (e.g. Niaz, Aguilera, Maza, & Liendo, 2002), conducting experiments (diSessa & Minstrell, 1998) etc. might be given as examples for conceptual change strategies. Results of studies in science education showed that these strategies are effective in promoting conceptual change than traditional approaches (Chambers & Andre, 1997; Hewson & Hewson, 1983).Aforementioned, scientific argumentation has an important role for the conceptual change (Baker, 1999) since argumentation has this potential naturally (Nussabaum & Sinetra, 2003). In other words, argumentation has the potential of determine and eliminate of alternative conceptions (Baker 1999; Nussbaum & Sinatra 2003; Jonassen & Kim, 2010). When students argue for an alternate opinion, the necessary processes for conceptual change are naturally occurred (Nussbaum & Sinatra 2003). In other words, when crafting an argument, students must consider in all parts of the issue, propound an explanation for the problem that are inconsistent with their existing conception, and must evaluate the differences between their opinions and the alternate ones. In this study, a scientific argumentation method that promotes conceptual change was followed as a conceptual change strategy.

2.5 Argumentation

The philosophical and cognitive basis of argumentation that used since around 500 B.C has been founded on Aristotle's Topics (Billig, 1989). Aristotle suggested three forms of arguments, namely analytic, dialectic and rhetoric arguments (Puvirajah, 2007). The analytic argument is linked between rationalistic paradigms. From the perspective of this paradigm, there is an absolute truth or reality that is objective and it can be found by any trained individual sooner or later.

The dialectical argument that is form of argumentation is an exchange of ideas through a dialogue. Dialectical argumentation mainly occurs when resolving disagreements through logical discussion (Puvirajah, 2007). In this form of argumentation, there are thesis and antithesis that two contradictory parties propose their claims, and they discourse until they achieve an agreement that is synthesis. The rhetoric form of argumentation aims to persuade the opponent to the validity of a claim verbally. In this form of argumentation, since the aim is to persuade the opponent by using evidences, witnesses, and documentation it is superior when compared with other forms of argumentation (Jimenez-Aleixandre, Rodrigez, & Duschl, 2000). Aristotle's argumentation forms provide a base for the consideration of argumentation in specific situations, such as judicial and parliamentary settings. From the perspective of Aristotle, when individuals pose their claims with their experiences, and social interactions, and inferences rather than universal principles in daily life, it is difficult to always justify claims with universal truths, or to achieve an agreement in every discourse.

The other argumentation theory is suggested by Toulmin (1958). Toulmin (1958), in his book of *The Uses of Argument*, developed a model, identified the elements of a persuasive argumentation and the relationships between them that help to analyze an argument (Figure 2.1). The key components of this model are:

- Data: Facts or evidences, which support the claim.
- Claim: A statement that includes information put forward for general acceptance.
- Warrants: Reasons proposed to justify the link between data and claim. If the warrant is not valid, the argument collapses.
- Backings: Basic supports, assumptions or justifications to back up the warrant.
- Qualifiers: Phrases that specify of limits to claim, warrant and backing
- Rebuttals: Situations under which the claim is refutable or undermined.

Toulmin’s argumentation model is a very useful model for analyzing the validity of an argument. According to Toulmin’s model, main components of an argument are “claims”, “data”, “warrants”, “backings”, “qualifiers”, and “rebuttals”. The claims are the conclusions or statements that include information; the data are the facts or evidences that support the claim; the warrants are the reasons that link between the data and the claim; and the backing is the theoretical assumptions to back up warrants. Qualifiers simply establish the boundaries of the claim and rebuttals are arguments that indicate situations under which the claim is refutable (Simon et al., 2006). In Toulmin’s argumentation, claim is the essential element for all arguments. Simon et al. (2006) made the definitions of argument and argumentation in order to make a distinction between argument and argumentation. They stated that, while arguments refers all components that contribute the process of discourse such as claims, data, warrants, and backings, argumentation refers the whole process of combining these components(Simon et al., 2006).

In order to generate good argument, the claim must be supported by providing a warrant and a backing. However, Driver, Newton, and Osborne (2000) exhibit that Toulmin’s argumentation has three limitations as following:

1. It only exhibits the structure of the arguments, but does not evaluate their correctness.
2. It does not take into account the dialogic structure of the argumentation and does not give interactional aspects of the argumentation.
3. Toulmin does not emphasize the situational context in his scheme (Driver et al., 2000).

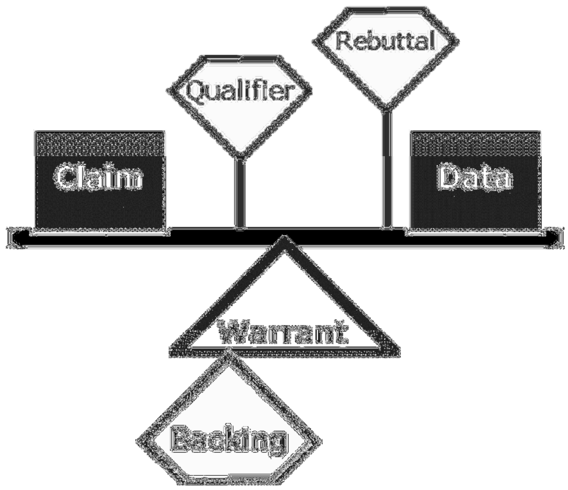


Figure 2. 1 Toulmin's argument pattern (Toulmin, 1958)

The third argumentation theory is identified by Walton (1996) who claims that argumentation is a fundamental part of an interactive dialogue when two or more people reasoning together. Walton (1996) indicated that argumentation schemes, which are grounded on practical arguments that can occur in a dialogue, can be used to evaluate everyday argumentation for presumptive reasoning. According to him, the presumptive reasoning plays a crucial role in argumentation that commonly occurs in everyday dialogues and it does not need to be inductive or deductive or does not need to be proved to be true (Walton, 1996).

2.6 Argumentation in Science

Over the past few decades, argumentation has been gained a place in the science context (Erduran, Simon, & Osborne, 2004). Research on argumentation in the science context has emerged in the 1990s (e.g., Driver et al., 2000; Lemke, 1990). The early researches were mostly related to Toulmin work (1958) (e.g., Osborne, Erduran, Simon, & Monk, 2001; Zohar & Nemet, 2002). Toulmin's definition for argument was used as an instructional tool for the analysis of a wide range of school subjects in different areas such as science (e.g. Jimenez et al, 2000; Zohar & Nemet, 2002) and history (Pontecorvo & Girardet, 1993). Particulary, in science education increasing number of research focused on scientific argumentation in the form of scientific knowledge (e.g. Driver et al.,2000; Duschl & Osborne, 2002; Erduran et al., 2004; Kelly & Duschl, 2002; Sampson & Grooms, 2009; Walker & Sampson, 2013; Zohar & Nemet, 2002).

In education, argumentation is defined as the evaluation of different perspectives to construct a view within an individual or within a social group to reach agreement on a claim or an action (Driver et al., 2000). In the context of science, basically, scientific argumentation defined as the process that scientists follow to support their claims with evidence that has been collected through observation or experimentation on the basis of reasons to rationalize why that evidence supports their claims by using logic (Sampson et al., 2010). Moreover, a scientific argument involves evidence and data rather than belief or opinions to support a claim since evidence is based on data gathered through an investigation that can be empirically verified, whereas beliefs and opinions cannot be empirically verified.

In a research, Norris, Philips, and Osborne (2007) defined scientific argumentation as "an effort to validate or rebut a claim on the basis of reasons that reflects the values of the scientific community" (p.227). In another research, Sampson and Grooms (2008) used a basic framework for the process of scientific argumentation around the elements of claim, evidence and rationale. According to Sampson and Grooms (2008), a scientific argumentation includes a claim that is a conclusion or an explanation supported by evidence and other reasons (Sampson & Scheigh, 2013). The term of "rationale" or "reason" refers "warrant" element in Toulmin's model and explains how the evidence supports the claim and also link between the evidence and the claim for the scientific argument. The term "evidence" is proper for "data" element in Toulmin's argumentation model and describes "measurements or observations" collected by the students that are used to support the appropriateness of the conclusion (Grooms, 2011). Briefly, students examine and evaluate data and then rationalize its use as evidence for a claim in scientific argumentation process (Walker & Sampson, 2013).

Argumentation have a vital role in the making explanations, constructing models and theories as the language of science is a discourse and scientist use arguments to link the evidence into explanations about related claims they attempt to reach (Driver et al., 2000). In literature, many of research in science education also reveals that argumentation promotes scientific literacy and encourages students to talk and write in the language of science as a way of knowing (Driver et al., 2000; Duschl & Osborne, 2002; Osborne et al., 2004; Jimenez-Aleixandre, 2007; Krajcik & Sutherland, 2010; Sampson & Walker, 2012; Walker & Sampson, 2013). Osborne (2005) stated that argumentation in science classrooms leads to students to gain and promote epistemological understanding about science through providing a conceptual understanding and developing an understanding about the construction of scientific knowledge. Gott and Duggan (2007) also claim that if students learn how to link warrants, qualifiers and backings between claims, scientific literacy will be easier. Hence, the capability to participate in productive scientific argumentation is viewed as a sign of scientific literacy (Duschl & Osborne, 2002; Jimenez-Aleixandre et al., 2000; Kuhn, 1993). In a study conducted by Walker and Sampson (2013), they found that students' oral argumentation and written argument scores significantly increased when they participated many of investigations based on argumentation. They also concluded that when students play a part in high quality collaborative argumentation they also craft higher level arguments in the context of science. Thus, students understand how scientific knowledge is constructed, justified, and evaluated by scientists and they understand to use those knowledge as a way of scientific literacy (Sampson &Clark, 2009; Walker & Sampson, 2013). According to Sampson and Grooms (2010) writing is one the most important aspects of science and scientists share the outcomes of their research and assess conclusions of others by writing. In addition, they highlighted that writing helps students improve metacognition and develop their understanding of the scientific content by thinking on their own writing. Since the argumentation encourages students to talk and write in the language of science as a way of knowing, designing learning environments to encourage students for verbal-communication and writing skills improve their conceptual understanding in science (Wallace, Hand, & Prain, 2004).

Scientific argumentation is also promotes critical thinking, whereas it also contributes the development of social interaction among individuals and communicative skills (Clark & Sampson, 2009; Driver et al., 2000) Also, collaborative argumentation not only gives opportunities to students to share their opinions with others but also provide view different perspectives of others through the process of an argument (Clark & Sampson, 2009).

In literature, there are many studies that reveals the benefits of collaborative argumentation (Cross et al., 2007; Sampson & Clark, 2009; Nussbaum, Sinatra, & Poliquin, 2008; Walker et al., 2012). To give an example, Sampson, and Clark (2009) investigated the effect of collaboration during scientific argumentation, studied with 168 high school chemistry students, who were randomly assigned to either collaborative argumentation or individual argumentation. The study results showed that the students, who worked in a group, generated high-quality arguments than the students who worked individually. Sampson and Clark (2009) specified that collaboration improved students' learning by giving opportunity to students to share their opinions and view different perspectives through the process of an argument.

Another study which investigate the role of argumentation in developing conceptual understanding, was conducted by Cross, Taasoobshirazi, Hendricks, and Hickey (2007). After 28 high school biology students engaged in collaborative learning of biology concepts, students' argumentation quality was evaluated by the help of pre-tests and post-tests. The study results showed that collaborative group work by engaging in arguments was improved students' understanding and achievement in science (Cross et al., 2007).

Nussbaum, Sinatra, and Poliquin (2008), designed a research, studied with 88 college undergraduates, who worked pairs and discussed to gravity and air resistance topics in physics in an online interface. First, students completed many surveys engaging in argumentations and in terms of results of these surveys they were categorized as relativists, multiplists, or evaluativists. Then, they read physic questions and discussed online with the other member of group collaboratively. Their discussion was analyzed whether claims are supported by facts, alternative theories are considered, and the argument includes for all facts and searches about the topic. Lastly, students' misconceptions' increase or decrease about new gaining physics concepts were observed. The research results showed that students who worked collaboratively achieve correct answers on physic concepts and generated high quality arguments.

In a different study, Walker et al. (2012), examined the effectiveness of ADI instructional model compared with the traditional laboratory sections in terms of undergraduate students' conceptual understanding of chemistry and attitude toward chemistry. During the study, students work worked collaboratively with others in order to offer and set investigations and spent time on main notions and ideas in a collaborative group. The study carried on 16 laboratory sections of introductory college chemistry and data collected with pre-post-test design. The results of this study indicated that students who worked collaboratively in the ADI sections showed improvement in terms of abilities to link between evidence and reasoning in argumentation process. On the other hand, it was found that there were no significant differences in conceptual understanding between the students in ADI sections and traditional sections.

Scientific argumentation is also promotes conceptual change. According to Nussabaum and Sinetra (2003) the potential of determining and eliminating alternative conceptions originates from nature of argumentation itself (Nussabaum & Sinetra, 2003). When students argue for an alternate opinion, the necessary processes for conceptual change are naturally occurred (Nussbaum & Sinatra 2003). when crafting an argument, students must consider in all parts of the issue, propound an explanation for the problem that are inconsistent with their existing conception, and must evaluate the differences between their opinions and the alternate ones. Consistent with the view of Smith, diSessa, and Roschelle (1993/1994) about conceptual change, argumentation is a constructive process in which knowledge is modified and reconstructed.

For example, Nussabaum and Sinatra (2003) conducted a study to investigate the efficacy of a conceptual change intervention based on argumentation with 41 undergraduate students in an educational psychology course. The students were randomly assigned as experimental and control groups. The experimental group students were asked to find in favor of an alternative scientific explanation of a physics problem and control group students who were only asked to answer the problem without any argumentation. The results of study showed that experimental group students display an improvement when reasoning on that problem than control group students. The results of study showed that the scientific argumentation was an effective method in order to improve students 'conceptual understanding, through taking their attention on important parts of the problem. The researcher also revealed that their results are consistent with other methods that support conceptual change such as making investigations and explanations (diSessa & Minstrell, 1998).

In another study, Bell and Linn (2000) used a computer-based assessment and asked students' 'How far does light travel?'' for constructing arguments. Although students did not require arguing the opposite side, their intervention resulted in conceptual change since the case was there. Therefore, they suggest that increase the time of instruction and number of problems in an argumentation process, endorses even more substantial conceptual change.

In another research, Barry (2011) investigated middle school students' conceptions about global climate change and the change these conceptions based on Argument-Driven Inquiry (ADI) model during an instructional unit. Students were implemented by three separate lessons within the unit, and each of lessons includes creating scientific explanations based upon evidence. In each lesson students were given data about global climate change and expected to work collaboratively to develop an explanation that accounted for the data. The students then evaluated the appropriateness of others explanations to determine if their explanations could be modified or not by peers. The data was collected by pre-unit, mid-unit, post-unit, and delayed-post unit interviews, observer notes from the classroom, a written post-assessment at the end of the unit and artifacts created by the students as individuals and as members of a group. The results of study showed that each student achieved some conceptual change regarding global climate change, although of varying natures. Moreover, findings showed that the students' poor ability to provide evidence in order to support their explanations was improved through the experience in the argumentation unit.

Moreover, recent studies showed that while arguing students not only learn to propound appropriate arguments but also learn science (e.g., von AufSchaniter et al., 2008, Jime´nez-Aleixandre & Pereiro-Munhoz, 2002). In addition, results of these studies that were used pre/posttest design documented that students' conceptual understanding increase when they are engaged in argumentation (Jime´nez-Aleixandre, Bugallo, & Duschl, 2000; Zohar & Nemet, 2002).

For example, Venville and Dawson (2010) made a study with 10th grade high school students in order to seek the effectiveness of argumentation on students' conceptual understanding on "genetics" concepts. The study was conducted with 92 students, who were randomly assigned to either experimental group or control group. The study results showed that the students, who were taught based on argumentation had scored performed significantly higher than the control group students on the post-test scores in terms of conceptual understanding of the genetics topics and generated high quality arguments.

The study conducted by Aydeniz et al. (2012) focused on the influence of argumentation-based treatment on college students' conceptual understanding of properties and behaviors of gases. They used quasi experimental method and collected data with pre-posttest design. The study was conducted with 52 students in the control group and 56 students in the experimental group in same general chemistry college course during six class sessions. The results of study indicated that students who were instructed argumentation-based instruction developed better conceptual understanding than those in the control group. Besides, students in control group had more alternative conceptions about gases concepts than experimental group students.

Further, von Aufschnaiter, Erduran, Osborne, and Simon (2008) conducted a study with junior high school students to seek the argumentation processes and students' scientific developments in socioscientific lessons. They recorded verbal conservations for small group discussion and whole-class discussions and evaluate the quality of students' arguments, and students' development in terms of using of scientific knowledge by using Toulmin's (1958) argumentation pattern. The research results showed that prior knowledge has an important role for generating good argument and students employ these knowledge and experiences at relatively high levels of abstraction. The results also suggested that argumentation make an increase abstraction of knowledge and enable students to evaluate their scientific understanding. Moreover, researchers stated that learning is a slow process and argumentation lead to improve conceptual understanding in the long term.

In her dissertation, Kıngır (2011) examined the effects of the SWH approach that is known argumentation-based science inquiry approach, on students' understanding and misconceptions of chemical change and mixture concepts. The sample of this study consisted of 122 ninth grade students and students were randomly assigned as control or experimental groups. A concept test was used to measure students' conceptual understanding and achievement about chemical changes and mixtures units as pre-test at the beginning of the instruction and post-test at the end of the instruction in both groups. The results of study illustrated that students who taught by SWH showed better conceptual understanding and fewer misconceptions than students who taught by traditional instruction. Moreover, it was concluded that students in experimental group developed positive attitudes toward chemistry.

Kaya (2013) made a study in order to inspect the effect of argumentation on pre-service teachers' understanding of chemical equilibrium. One hundred pre-service teachers enrolled in two classes in the study. One of the classes was randomly chosen as control group and the other one as experimental group. In experimental group, argumentation based instruction was taught during teaching chemical equilibrium subject while control group was taught by traditional instruction. "The Chemical Equilibrium Concept Test" and "Written Argumentation Survey" were applied to students in order to evaluate their conceptual understanding and the quality of their arguments. The results of research showed that argumentation enable to experimental group students improve conceptual understanding when compared to the control group students. The results also indicated that pre-service teachers who were taught by argumentation based instruction generated more quality arguments than those in the control group after the instruction.

As aforementioned, since the scientific argumentation has a big influence in the development, evaluation, and validation of scientific knowledge, the current research in science education suggests integrating argumentation in the teaching and learning (e.g. Bell & Linn 2000; Driver et al., 1994; Duschl, 2000; Zohar & Nemet 2002). In order to support teaching and learning of argumentation in science classrooms, one of the way is to design effective learning environments and evaluate the effectiveness of instruction with appropriate tools. As a result, science educators have focused on designing effective learning environments that includes promoting argumentation practices into the classroom (Simon et al., 2002). Several studies revealed that the use of scientific argumentation as an instructional strategy gives students an opportunity to learn how to participate in the process of science firsthand (Driver et al., 1994; Duschl, 2000), and to develop a better understanding of important content knowledge (Bell & Linn 2000; Zohar & Nemet 2002). Furthermore, current research showed that by engaging in argumentation as part of the inquiry process can improve students' investigative experiences (Sandoval & Reiser 2004; Tabak, Smith, Sandoval & Agganis, 1996).

On the other hand, scientific inquiry refers to the varied ways in which scientists use to investigate the real world and put forward explanations based on the evidence derived from their investigations (NRC, 1999, 2000; Sampson & Scheigh, 2013). Scientific inquiry reflects how scientists understand the world as well as the activities that students engage in when they try to develop an understanding in science context (NRC, 1999). Thus, in the process of learning with scientific inquiry, students learn to conduct an investigation to answer an investigable question and collect evidence from different of sources, and then try to reach an answer for their question to develop an explanation which is based on data gathered through an investigation, and defend their conclusions. From this aspect, scientific inquiry has a similar construct with argumentation in science context inside the classroom (Sampson & Scheigh, 2013).

There are a number of strategies to integrate argumentation into the teaching and learning of science with inquiry (Bybee et al., 2004; Carin et al., 2005; Cavagnetto, 2010; Clark & Sampson, 2007; Eisenkraft, 2003; Erduran et al., 2004; Kıngır et al., 2012; Marek & Cavallo, 1997; Sampson & Gleim, 2009; Sampson et al., 2009; Simon et al., 2006; Simonneaux, 2001; Walker & Zeidler, 2007).These studies emphasize that scientific argumentation plays an important role in science learning (Duschl & Osborne, 2002; Jiménez-Aleixandre et al., 2000; Kelly, Druker, & Chen,

1998) and more inquiry based instructions should be supported and promoted in science classrooms (Walker et al., 2011).

In this study, Argument-Driven Inquiry (ADI) instructional model was used as the combination of scientific argumentation and inquiry (Walker et al., 2012; Walker et al., 2011).

2.7 The Argument –Driven Inquiry (ADI) Instructional Model

The ADI instructional model was originated in undergraduate students and implementation of ADI in undergraduate began to in the 2009 (Walker et al., 2012). This instructional model is a laboratory based model that includes inquiry and exploration in science education that contribute the importance of argumentation in science (Osborne et al., 2012; Walker et. al., 2012). This model provides a wide range perspective by combining argumentation with laboratory based instruction (Walker & Sampson, 2013). According to Sampson et al. (2013), the model is developed to the aim of scientific inquiry as an attempt to craft an argument that provides and supports an explanation for a researchable question (Sampson & Gleim, 2009).

The roots of ADI instructional model comes from social constructivist theories because it promotes critical thinking and reasoning skills by the inquiry based laboratory activities with collaborative group work (Walker & Sampson, 2013). Peer collaboration is the notion of ADI instructional model. When peers come together to accomplish a task cooperatively, this social interaction can lead learning. Therefore, roots of ADI come from the social constructivist theories. The ADI instructional model also encourages students to propound a scientific method to be followed during an investigation in order to answer a research question though the process of learning scientific concepts with inquiry, argumentation, and writing in science and engage in peer review (Sampson, Grooms, & Walker, 2010; Sampson & Gleim, 2009).As part of this model, teachers can help provide learning environments that is more educative and useful for students since the structure of the model serves as a guide for teachers (Sampson et al., 2013). Moreover, this instructional model can help teachers who want to help students develop a better understanding in science

(Sampson & Gleim, 2009). The seven steps of ADI instructional model are propound to associate the learning of scientific concepts with inquiry, argumentation and writing (Walker & Sampson, 2013).

The ADI process was defined as follows (Sampson, Grooms, & Walker, 2009; Walker, Sampson, & Zimmerman, 2011):

1) The identification of the task or a research question
2) The generation of data through systematic observation or experimentation
3) The production of tentative arguments
4) Argumentation session
5) The creation of a written investigation report
6) Double-blind peer-review
7) Revision of the report based on the peer review

The implementation of ADI starts with a major topic to be investigated by students. Instructor gives a researchable question which is needed to answer. The students work with collaborative group to develop a method in order to answer question provided by instructor (Walker et al., 2011). During investigation, procedures being followed by students are uncertain. Because the uncertain nature of procedure, students are provided an opportunity about how to carry out an investigation to reach knowledge. In other words students are expected to understand the way scientist follow by doing science through designing method, interpret empirical data and evaluate new explanations (Sampson & Grooms, 2008).

The first step of the ADI instructional model is "identification of task" that was designed to introduce the topic and take attention of students (Walker et al., 2012). In this step, first the teacher introduces the major topic to be studied. The main aim of this step is to take attention of students to the studied topic similar to the other instructional models such as 5E learning model (Carin & Bass, 2001) or Science Writing Heuristic approach (Keys, Hand, Prain, & Collins, 1999). The students were provided an activity sheet that includes information about the topic and a research question to answer by using given material in the sheet during the laboratory investigation. The activity sheet also included a material list that could be used during the investigation and some clues or recommendations to help the students when starting the investigation (Sampson et al., 2011). Students were asked to propose an appropriate investigation method to answer the research question. At this point, the students were expected to make brainstorming about the solution of the research question and they were asked to suggest a method for laboratory investigation.

The second step of ADI model emphasizes the “generation and analysis of data”. At this step, students work collaboratively to develop a method in order to find an answer for research question (Walker et al., 2011; Walker & Sampson, 2013). During this step, students are provided an opportunity to learn design and carry out an investigation and how to use appropriate tools and collect data through the empirical work. To be clear, teacher provides only research question and students are expected to design the method to test question and find an explanation for this. Thus, the nature of these investigations refers “guided inquiry”. Further, this step can provide a firsthand experience for students who never have such an opportunity to develop their own methods to answer a research question (Walker, 2011). Perhaps the most difficult part is this part for students and teachers because students used to follow step-by-step procedure in traditional laboratory courses and teachers used to answer questions directly. So at this step, students needed more guidance as to whether their investigation plans make sense.

The third step is the “production of a tentative argument”. At this step, students construct an argument as a solution of research question that involves explanation in other means claim supported by evidences and reasons based on their data and observations. This step involves putting forward a claim about the natural world and attempt to support this claim with appropriate reasons and evidences with collected data, this is considered one of the most important element in science learning (Driver et al., 2000). In other words, students need to understand the way of scientist follow that they use theories laws or models to design new investigation in order to interpret empirical data and support their claims with appropriate reasons and evidences. In this step the focus is the importance of argumentation in the science context (Walker, 2011; Walker et al., 2011, 2012; Walker & Sampson, 2013). Moreover, this step allow to students to make ideas, evidence, and rationale clear for each other. Thus, they can evaluate others' explanations, claims, and data to decide which the most acceptable alternative is or which are the inaccurate in terms of collected data in the next stage of the instructional model (Walker, 2011).

The fourth step is named as "argumentation session". This step gives students an opportunity to evaluate others' explanations, claims, and data to decide which is the most acceptable. Each group share their answers, on the one hand students justify their own claims; on the other hand they refute some elements of arguments claimed by others that is inappropriate for them. By the help of argumentation session students learn to critique the components of argumentation such as claims, evidences etc. This step is also have importance since the current research indicates that students often hold an alternative conceptions about a given phenomenon and most of the students could not evaluate the appropriateness of others' explanations by using scientific perspective (Hand, Norton-Meier, Staker, & Bintz, 2009). The argumentation session embedded in this instructional model allow to students learn how to interpret scientific theories or laws to fit with data and eliminate inappropriate ones that inconsistent with the available data. Students also have opportunity to change or improve on their first ideas or methods. It also gives teachers a chance to consider students' ideas and to encourage them to think about concerns that may have been ignored (Walker, 2011).

The fifth step of the ADI instructional model is the "generating a written investigation report" by individual student. Students are required produce an investigation report based on ADI instructional model. The aim of this report is to understand the goal of investigation and learn to write in science. According to Wallace et al. (2004) the writing process encourages metacognition and improve student understanding of the content and develop a conceptual understanding for scientific inquiry.

The investigation report written in ADI format is dissimilar to the traditional laboratory format in many ways. The ADI instructional method gives students opportunities to participate in laboratory investigations as a part of process by requiring them designing methods to address the given research question and conduct appropriate investigations. In the ADI instructional model, students propound claims and support them with evidence and reasons. The ADI instructional model provides a non-traditional report format because most students lack the content knowledge and the skills needed to write well in science (Kelly et al., 2007). Thus, ADI report format was designed to support students learn to write in science and to help them better understand the content (Sampson, Walker, & Grooms, 2009). In order to support students learn to write in science, ADI report is organized into six parts around six essential questions: Which method did you follow during investigation? What are your observations and data? What is your claim? What are your evidences to support your claim? What is your reason to prove your claim? Which are your changed ideas?

The sixth step of the ADI is called a “double-blind peer-review” that ensures the quality of these reports. After students complete their investigation report, the teacher randomly distribute the reports of other groups to each other group. With the aim of engagement in the evaluation process inserted in the model, students assess the other groups’ reports with a peer review sheet as a part of double blind peer review. The groups review each report and then evaluate whether it needs to be revised with regard to questions involved on the peer review sheet. The peer review sheet includes a criterion list to evaluate quality of other groups’ laboratory reports and organized around three questions: Did the group provide an appropriate claim based on research question? Did the group provide an appropriate evidence to support their claim? Did the group provide an appropriate reason to support their evidence? Each group reviews the others’ report as a group and then decides whether it could be valid or needs to be revised in the light of criterion list.

To be clear, this step involves an educative feedback for students. Students are required to read, understand and evaluate the quality of science writing. In order to meet this requirement they need to learn how to evaluate the quality of an argument in science. Once they succeed it, they could develop metacognitive skills during this process. Thus, they could decide validity or acceptability of a claim or evidence as a part of investigation when criticizing each other’s writing.

The seventh and final step of this model is the modification of the investigation report with regard to the results of the peer-review (Walker, 2012). At this step, all students are given opportunity to rephrase their reports based on the other groups' critics of other groups. Students whose investigation report was not found appropriate by their peers are required to revise their reports based on the classmates' suggestions and feedbacks (Walker, 2011, 2012). Once completed, the final form of the reports is submitted by the teacher. The major goal of this step is giving students an opportunity to improve their writing, reasoning and to develop better understanding in science through engaging writing process in the context of science (Walker, 2011).

In summary, the ADI instructional model gives students an opportunity to engage in science with many of activities such as inquiry, argumentation and writing. For instance, engaging in inquiry, students conduct an experiment, make observations, draw graphs etc. and collect data in order to make an explanation for a natural phenomenon. In other respects, during scientific argumentation, students generate a claim and support their claim with reasons and evidences that they gathered during investigation. So, students could develop better scientific arguments supporting explanations in regards to natural phenomena (Groom, 2011). Moreover, argumentation session encourages students to interact with each other and make contribution to improve their social interaction. In regard to science writing process, students learn to put into words what they thought clearly and their thoughts could be visible to each other (Walker et al., 2012). In this current study, the Argument-Driven Inquiry (ADI) instructional model that enhances opportunities for students to engage in scientific argumentation and inquiry was used.

2.8 Previous Research on ADI

As aforementioned, the ADI instructional model was originated in undergraduate students and implementation of ADI in undergraduate began to in the 2009 (Walker et al., 2012). Since the ADI is a new instructional model in science, yet there are limited studies in the literature. In addition, many of these studies were administered in the USA. These studies are concerning the effectiveness of ADI instructional model with respect to students' conceptual understanding in science, investigating the effectiveness of ADI on students wiring skills, argument skills, and attitudes toward science and examining nature of the arguments that students create during laboratory activities. These studies conducted in worldwide are reviewed in detail.

In a study conducted by Sampson, Grooms and Walker (2010), the effect of the ADI instructional model on students' participation in scientific argumentation and the quality of the arguments that they generated were examined. The study focused on examining nature of the arguments that students create during laboratory activities. Nineteen tenth grade students were enrolled in this exploratory study. The researchers used a performance task in order to compare student performance on this task before and after an intervention that involved 18 ADI laboratory sessions. The results of study revealed that students' ability to join a scientific argumentation improved over the course of the intervention. Their analyses also suggest that the students had better disciplinary engagement and all the groups were able to generate higher quality written arguments after the intervention.

In another study, Enderle, Groom, and Sampson (2013) conducted a study with 256 high school students to compare the effectiveness of ADI approach over traditional approach in terms of students' content knowledge in biology. They used four different assessments including Biology Content Knowledge Assessment, Science Specific Argumentative Writing Assessment, Biology Performance Task Assessment, and Student Understanding of Science and Scientific Inquiry instrument in order to investigate the changes students' performance on each assessment over time at the beginning and end of the research. All of the assessments were scored using rubrics developed by the researchers. The results of the study showed that the students in both groups made statistically significant gains in terms of their content knowledge. However, only the students who participated in ADI laboratories made significant gains in terms of their scientific writing abilities and their understanding of the development of nature of scientific knowledge. Further, the results of this study suggest that the ADI instructional model has a potential to improve students' science proficiency and contributes to the research about understanding the learning of critical thinking skills.

The study conducted by Walker, Sampson and Zimmerman (2011) focused on the introduction of ADI instructional model to use in undergraduate college chemistry laboratory courses. The study indicates a detailed “semester schedule” for general chemistry I laboratories, “peer-review guides”, and “instructor scoring rubrics” for undergraduate level. In another but similar article, Sampson, Groom and Walker (2009) introduce the ADI in detail.

Sampson and Walker (2012) made a study to examine influence of ADI on students’ scientific writing. The study took place over a 15-week semester and involved six laboratory activities. After each laboratory investigation based on ADI, students write laboratory reports. Then, researchers examined the changes in these reports with regard to students' writing skills over time for the undergraduates in science context. Each researcher scored the students’ reports with a rubric developed by them. The analysis of the reports showed that students improve their science writing skills over the course of a semester. Moreover, they succeed evaluate the quality of their peers' writing with high appropriateness.

In his dissertation, Walker (2011) investigated the developments of undergraduate students’ crafted arguments and the scientific argumentation in a chemistry course during a term. Students joined in two sections of “General Chemistry I laboratory” at a community college and worked collaboratively in groups of three or four. The 23 students participated in each section. The students were given a variation of the same performance task three times during the terms to assess the quality of generated arguments. During the semester, five ADI investigations were implemented and students write the laboratory reports for each and each report was scored by researchers. Students were evaluated with regard to improvement in argumentation, written argument and performance task over the course of the semester. Therefore, groups were video recorded five times to evaluate arguments and group argumentation was assessed with an instrument developed by researcher. The results of the study indicated a significant growth for “performance-based assessment”, “written argument” and “oral argumentation”. Moreover, the researchers suggest that there was a significant correlation between written and oral arguments whereas oral argumentation was a predictor of written argument (Walker & Sampson, 2013).

In another study, Walker, Sampson, Zimmerman and Grooms (2011) developed a performance-based valuation instrument to measure student conceptual understanding about the role of reactants in chemical reactions to be used in ADI instructional model. They prepared a laboratory investigation including a set of balloon-covered flasks to mixture constant volumes of 1 M acetic acid with rising quantities of sodium in balloons for students. Students mixed sodium bicarbonate with acetic acid from the balloon into the flask and detected the color change of the solution. Then, students were asked to write an assessment following the laboratory investigation on limiting reactants in chemical reactions to measure conceptual understanding. In the assessment tool, overall information about the reaction and students were requested to find the limiting reactant in each flask, and provide evidence and their reasoning for this conclusion. The students' marks were ranged from 0 to 26, in which zero scores shows lack of conceptual understanding on limiting reactant. It was stated that with the help of this assessment tool, the student's capability to utilize evidence to support an argument or statement was measured. Researchers also emphasized that this tool gives opportunities to students for group discussion.

The study conducted by Grooms (2011), examined the comparison of ADI instructional model with more traditional instruction in terms of their stance in the context of a Socioscientific Issue. The researcher used quasi-experimental method and collected data with pre-post-tests with the required time intervention. The study was conducted with 73 students in the treatment group and 79 students in the control group in same general chemistry laboratory course offered at neighboring institutions. The study included eleven investigations for both the comparison group and treatment group during a 15-week timeline. During the study, students were presented different tasks in the form of a short narrative and two competing television commercials. After the students read the narrative and watched the commercials for each task they finalized a follow-up questionnaire. The students completed these two tasks at start and at the end of the semester to decide if there were any changes from before to after the intervention. The findings of study indicated that students who took instruction based on ADI have better arguments although they have less epistemological sophistication. On the contrary, the control group students experienced a reduction in the sophistication of their arguments. Further, none of instructional strategy was effective to change students' epistemological sophistication toward an evaluativist stance. In addition, the students within the ADI treatment group became more scientifically literate, than those in the traditional course.

In a study conducted by Walker, Sampson, Grooms, Anderson, and Zimmerman (2012), researchers investigated the effectiveness of ADI instructional model compared with the traditional laboratory sections in terms of the undergraduate students' conceptual understanding of chemistry and attitude toward chemistry. The participants of study were 372 community college students. The study carried on 16 laboratory sections of introductory college chemistry and data collected with pre-post-test design. Researchers measured students' conceptual understanding with a multiple choice concept test, used two different performance tasks for written arguments and administered an instrument to measure students' attitude toward science during three semester in General Chemistry I laboratory lecture. The outcomes of the study showed that students in the ADI sections presented improvement in terms of abilities to utilize evidence and reasoning. On the other hand, it was found that there were no substantial alterations in conceptual understanding between the students in ADI sections and traditional sections. Additionally, the female students in the ADI classes had more positive attitudes headed for science at the end of the semester in comparison with the female students in the traditional classes. One of the limitations of this study is that while the control group students completed 11 laboratory investigations, the ADI group students were participated six investigations because of the required time to complete all seven steps of the model.

Sampson, Enderle, Grooms, and Witte (2013) conducted another study to investigate the change middle school and high school students' science-specific argumentative writing skills and understanding of basic concepts altered during the semester. 294 students took part in this study from two middle and two high schools. Students participated many of science laboratories designed based on Argument-Driven Inquiry (ADI) instructional model. The study continued over two semesters and included minimum eight laboratory investigations in each lecture. Student education acquisitions were measured using a science content assessment tool which is an open-ended instrument to evaluate students' understanding of basic scientific concepts and a science-specific argumentative writing assessment that were applied at the start, in the middle, and at the end of the term. The findings indicated that students' science-specific argumentative writing skills and their understanding of basic concepts in science developed over time during course. Moreover, students who participated more ADI activities in course showed a greater and more consistent improvement in their writing.

2.9 Attitude and Gender

Besides the cognitive variables, measuring affective variables is very important in the context of education. In the literature, it was demonstrated that affective variables have a big influence on student achievement in science (Chandran, Tregaust, & Tobin, 1987). Many of studies investigated the role of affective variables such as attitudes, values, beliefs, feelings, and motivation, on students' achievement in science context (e.g. Bennett, 2001; Dindar, 2011, Hough & Piper, 1982; Marsh, 1992; Neathery, 1997; Oliver & Simpson, 1988; Talton & Simpson, 1987, Walker et al., 2012).

One of the primary aims of science teaching is to support learners to improve more positive attitudes towards science on the account of improving the students' understandings of science. The meaning of the term "attitude" is examined as two different constructs: scientific attitudes and attitudes toward science in the context of science. The scientific attitude refers the behaviors related to ways of students' thinking or a scientific method (Bennett & Hogarth, 2005), where attitude toward science term defined as "a person's positive or negative response to the enterprise of science…whether a person likes or dislikes science" (Simpson, Koballa, Oliver, & Crawley, 1994, p.213). In this current study, "attitude toward chemistry" which refers to the feelings of students toward chemistry was examined.

In science education, as well as teaching strategies, it was recommended that students' attitudes towards science should be taken into account since it is also essential in order to improve the quality of science education (Koballa &Glynn, 2007). It was concluded that students' attitudes toward science has an important role in order to develop a comprehensive conceptual understandings in science concepts (Nieswandt, 2007). Moreover, students' attitudes are also associated with their achievement and the development of positive attitudes toward chemistry could motivate students to learn chemistry (Osborne et al., 2003).

There are numerous research on attitude in science education that indicate confirmation for the relationship between students' attitudes in the direction of school science and their academic achievement (e.g., Neathery, 1997; Osborne & Collins, 2000; Simpson & Oliver, 1990). Many of these studies offer moderate correlation between attitude towards science and achievement (Osborne& Collins, 2000; Simpson & Oliver, 1990; Weinburgh, 1995). For example, Weinburgh (1995) conducted a meta-analysis research which suggests that there is a moderate correlation among learners' attitudes towards science and their academic success and it was come up as 0.50 for boys and 0.55 for girls. In another study, Marsh (1992) studied with eighth and tenth grade Australian schoolboys and showed the correlation among attitude toward science and success in science as 0.70. Oliver and Simpson (1988) obtained a strong relationship between students' attitudes toward science and their achievement in science in a longitudinal study. Neathery (1997) investigated the correlations of students' attitudes toward science with gender, achievement, ability and ethnicity and found a significant relationship for achievement, gender, and ability.

The teaching method in science classroom is one of important factors that have a big influence on improving students' attitudes toward science. Students who have an effective teaching method and an effective learning environment have more positive attitudes than the students who did not have (Germann, 1988). In literature, many of studies reported positive outcomes of various teaching methods on students' attitudes toward science such as learning cycle (Aydemir, 2012; Ceylan, 2008), problem based instruction (Serin, 2009; Şenocak, Taşkesengil & Sözbilir, 2007), conceptual change approach (Ceylan & Geban, 2010; Kaya, 2011; Uzuntiryaki & Geban , 2005), and

SWH approach (Günel, Kabataş-Memiş & Büyükkasap, 2010; Kabataş, Günel, Büyükkasap, Uzoğlu, & Hand, 2008, Kıngır, 2011).

Talton and Simpson (1987) highlighted the importance of correlation between the learning setting and approaches headed for science. In their study, Koballa and Gylnn (2007) stated the role of instruction on students' positive attitudes toward science. To be clear, they revealed that students who have more positive attitudes are more willing to involve in class activities and would be more successful in science classrooms (Koballa & Gylnn, 2007). Moreover, it was concluded that laboratory-based instruction promotes students' acquisition of scientific conceptions and positive attitudes toward science (Erkol, Kışoğlu, & Büyükkasap, 2010; Freedman, 1997). ADI instructional model is a way of creating new classroom environments that enable students a first-hand laboratory investigations by enhancing active learning with various activities and helps students understand how scientific concepts related to nature of science. Therefore, ADI instructional model studies also point out the impact of ADI on improving students' attitudes toward science (Walker et al., 2012).

There were limited studies using ADI instructional model to investigate its effect on students' attitudes toward science since the ADI instructional model is new in the educational context, (Walker et. al., 2012). In a study conducted by Walker et al. (2012) 372 community college students were participated. The study carried on 16 laboratory sections of introductory college chemistry and data collected with pre-post-test design. Researchers administered an instrument to measure students' attitude toward science during three semesters in General Chemistry I laboratory course. The instrument was used to measure students' attitudes toward science with scale named as the "Attitude Toward Science In School Assessment" (ATSSA; Germann, 1988) and researchers adapted the ATSSA to apply chemistry laboratory. The instrument covered 15 questions and it was a 5-point Likert scale ranges from 1 (strongly disagree) to 5 (strongly agree). The minimum score was 15, and maximum score was 75 for the total attitude score. The reliability of the instrument was measured by Cronbach's alpha, and found as .91. The results of this study indicated that students in the ADI sections (M = 58.00, SD = 8.42) showed more positive attitudes toward chemistry when compared students in traditional chemistry instruction (M = 54.30, SD = 11.64) at the end of the term. More specifically, the girls in the ADI class had more positive attitudes towards chemistry at the end of the term than boys in the traditional classes.

The relationship between attitude and achievement is also affected from various factors such as gender, early childhood experiences, classroom organization, teacher authority and the nature of classroom (Pintrich, Marx, & Boyle, 1993; Osborne et al., 2003). More specifically, gender is one of the most significant factor that influencing students' attitudes toward science (Osborne et al., 2003). Many studies report differences in attitudes of both genders in favor of boys which mean boys have a more positive attitude toward science than girls (Koballa & Gylnn, 2007, Simpson & Oliver, 1985; Rani, 2000; Reiss, 2004**;** Weinburgh, 1995). To give an example, Weinburgh (1995) carried out a meta-analysis of 18 studies including 6753 students (3337 boys and 3416 girls) and found that male students consistently indicated more positive attitude towards science. In a longitudinal study, Reiss (2004) examine the effect of gender differences on attitudes toward science and concluded that male students have a more positive attitude toward science than girls. In another longitudinal study, Breakwell and Robertson (2001) explored the changes in students' attitude towards science during ten years. The findings of study showed that male students had more positive attitudes and better performance in science than female students. Similarly, Salta and Tzougraki (2004) conducted a research including 576 high school students in Greece and showed that although there were not any differences in terms of students' gender in their attitudes as regards interest, usefulness, and importance of chemistry, female students had more negative attitudes with regard to the difficulty of chemistry course as compared to boys. However, some of the studies reported that girls have more positive attitudes towards science than boys (Akpınar, Yıldız, Tatar, & Ergen, 2009; Dhindsa & Chung, 2003; Walker et. al., 2012).

In conclusion, attitude towards science in other words interest in science can be improved by effective teaching methods, curriculum or the supportive classroom environment (Walker et al., 2011). ADI instructional model is a way of creating new classroom environments to promote students' conceptual understanding with various activities. Therefore, one of the focuses of this study was to investigate the relationship between students' attitudes toward chemistry and method used to during study by taking gender issue into account.

CHAPTER 3

METHOD

In this chapter, design of the study, population and sample of the study, variables, instruments, research design, data collection and analysis, procedure, treatment, treatment verification, power analysis, internal validity, limitations and assumptions of the study are explained briefly.

3.1 Design of the Study

In this study, non-equivalent control group design was used which is a type of quasi-experimental design. Argument- Driven Inquiry (ADI) was implemented in the experimental groups and traditional chemistry instruction (TCI) was implemented in control groups. Moreover, classes were chosen randomly as experimental group and control group. There were two 45-minute sessions per week for both of the groups and the treatment was conducted over seven weeks. Table 3.1 shows the design of the study.

Table 3. 1 Design of the study

Groups	O (Pretest)	X (Treatment)	O (Posttest)
EG	GCT ASTC ASTA	ADI	GCT ASTC ASTA
CG	GCT ASTC	TCI	GCT ASTC

The meanings of the abbreviations in Table 3.1 are given below:

EG: Experimental Group

CG: Control Group

ADI: Argument-Driven Inquiry

TCI: Traditional Chemistry Instruction

ASTC: Attitude Scale toward Chemistry

ASTA: Argumentativeness Scale toward Argumentation

GCT: Gases Concept Test

3.2 Population and Sample

The target population of the study contains all tenth grade high school students registered in a chemistry course in Ankara which is the capital of Turkey. The accessible population is all tenth grade students at public high schools in Yenimahalle, Ankara. The sample of this study was determined by choosing a public high school from the accessible population by using convenience sampling approach. In this high school, six intact classes of a teacher were participated in this study. Thus, the same teacher instructed both control and experimental groups in the school. The teacher was male.

The sample of this study consisted of 157 tenth grade students from one public high school. There were 82 students (46 males and 35 females) in the experimental groups and there were 75 students (29 males and 46 females) in the control groups. 51.9% of the participants were female and 48.1% were male.

3.3 Variables

There are eight variables in this study, three of them are determined as dependent and five of them are determined as independent variables.

The dependent variables of the study are students' understanding of gases concepts measured by Gases Concept Test-II (PostGCT), students' attitudes toward chemistry measured by Attitude Scale toward Chemistry (PostASTC), and students' tendency of argumentation measured by Argumentativeness Scale toward Argumentation (PostASTA). All dependent variables are continuous variables and were measured in interval scale.

The independent variables of the study are pretest scores on Gases Concept Test-I (PreGCT), pre-test scores on Attitude Scale toward Chemistry (PreASTC), and pre-test scores on Argumentativeness Scale toward Argumentation (PreASTA). These independent variables have potential to become a covariates in order to control pre-existing differences between groups. Pre-test scores of all scales were considered as continuous variables and were measured in interval scale. The other independent variables are treatment (Argument- Driven Inquiry and traditional chemistry instruction) and gender (male and female). These are categorical variables and measured on nominal scale. The characteristics of all variables are shown in Table 3.2.

Table 3. 2 Identification of variable

Name of Variable	Type of variable	Type of Value	Type of Scale
Treatment	Independent	Categorical	Nominal
Gender	Independent	Categorical	Nominal
PreGCT	Independent	Continuous	Interval
PreASTC	Independent	Continuous	Interval
PreASTA	Independent	Continuous	Interval
PostGCT	Dependent	Continuous	Interval
PostASTC	Dependent	Continuous	Interval
PostASTA	Dependent	Continuous	Interval

3.4 Instruments

The instruments used in this study are Gases Concept Test-I(GCT-I) as pre-test, two-tiered Gases Concept Test-II(GCT-II) as post-test, Argumentativeness Scale toward Argumentation(ASTA), Attitude Scale toward Chemistry(ASTC), interview schedule, and classroom observation checklist. In the following section, instruments are explained in detail.

3.4.1 Gases Concept Test-I

This test was developed by the researcher to assess students' understanding of general properties of gases, diffusion of gases, gas laws, and ideal gases in order to control pre-existing differences between groups. In other words, this test was also aimed to have opinion of equality of groups at the begging of the study.

According to new Turkish national curriculum, starting from the beginning of six grade students are given formal instruction about "states of matter", "particulate nature of matter", "change of state", "properties of gases" and "pressure of gases" to end of the middle school. It means tenth grade students had been taught about these concepts during the first years of middle school as a part of science and technology classes. Since the students had some pre-existing knowledge about these concepts before the implementation, scores of this test were used to compare whether students have difference for previous learning in means of conceptual understanding of gases in ADI and TCI groups. So, the GCT was applied at the beginning of the study as a pre-test. During the development process, first, national chemistry curriculum was examined by taking into account instructional objectives of gases concepts. Then, students' alternative conceptions in gases concepts were determined by examining related literature (Lin et al., 1996; Niaz, 2000; Azizoğlu, 2004; Çetin, 2009). Following this step, some of the questions were obtained from the literature and some of them were developed by considering of the objectives of subject (Niaz, 2000; Çetin, 2009; Kıngır, 2011; Şahin & Çepni, 2012). Finally, after some revisions, the test items were constructed according to instructional objectives of gases concepts. The test included 20 multiple choice items consisting of one correct answer and four distracters. Distracters included possible alternative conceptions of students on gases concepts. When scoring, each correct response was considered as 1, and each incorrect response was considered as 0. Therefore, the maximum score that a student can take from this test was 20, and the minimum score was 0.

The face and content validity of the test was examined by the 6 chemistry education experts with regard to relationship between questions and instructional objectives by using a table of specification checklist (see Appendix C). Also the test was controlled in terms of its grammar and understandability. It provides an evidence for face validity. Some distracters and items were improved by taking into consideration the experts' feedbacks.

Before the treatment, Gases Concept Test-I was applied to 186 (52% females, 48% males) tenth grade students from two high schools as a pilot test to evaluate reliability aspects of this test scores during the fall semester of 2012-2013. The Cronbach alpha reliability coefficient was computed as 0.67 for GCT-I. Lastly, the revised test was administered students beginning of the treatment (Appendix D).

3.4.2 Gases Concept Test-II

The GCT-II was a two-tier test developed by the researcher to measure students' understandings of gases concepts and identifies their possible alternative conceptions. In order to strengthen the multiple-choice tests, two-tier tests were developed (Tan et al., 2002).

Although a multiple choice concept test was applied to students at the beginning of the study, the researcher decided to use different but equivalent form of GCT-I to obtain strong evidence of reliability with regard to consistency over time at the end of the study. The equivalent- forms method is one of the best ways to obtain reliability coefficient. Since the students take the same test more than once, they could perform same and their answers could cause errors of measurement (Frankel & Wallen, 2006). On the other hand some questions are same with the GCT-I, since the time interval between two administrations is appropriate -6 weeks- the combining test-retest and equivalent form methods increase the probability of obtaining strong reliability evidence. So, the GCT-II was applied as a post test at the end of the study (Appendix E).

In order to diagnose students' alternative conceptions on a specific topic, many different methods used such as interviews (Osborne & Gilbert, 1980; Thompson & Logue, 2006), concept maps (Tsai & Chou, 2002), open-ended questions (Çalık &

Ayaş, 2005), and multiple-choice questions (Halloun & Hestenes, 1985; Tamir, 1971 as cited in Tregaust, 1986). All of these methods both have some advantages and disadvantages. While multiple choice tests have advantage over interviews in terms of being applied great number of students in short time and easy assessment, interviews are superior to multiple choice tests in terms of providing deeply investigation of students' answer (Peşman, 2005). To overcome limitations of these methods two-tier multiple choice diagnostic test was suggested by Treagust to diagnose students 'alternative conceptions (Treagust, 1986; Treagust, 1995).

In a diagnostic two tier test; the first tier represents an ordinary multiple choice question and second tier includes the reason for the answer of first tier in multiple-choice format (Tan et al., 2002; Treagust & Chandrasegaran, 2007). The incorrect reasons in second tier include students' alternate conceptions related to a specific content area gathered from literature, interviews, or open-ended questions. In the literature a considerable amount of diagnostic test have been developed by researchers and have been used for diagnose alternative conceptions in chemistry (Chou & Chiu, 2004; Coştu, Ayaş, Niaz, Ünal, & Çalık, 2007; Kırbulut, Geban, & Beeth, 2010; Odom & Barrow, 1995; Treagust, 2006; Wang, 2004).

The use of diagnostic two-tier test not only provides to identify students' alternative conceptions but also to probe the reasons behind the explanations of students (Tsai & Chou, 2002). Moreover, a two-tier test has the ability to administer a great number of students and allow teachers to analyze answers of students objectively. Therefore, two tier tests have been used for diagnostic assessment in the literature for a long time (Tsai & Chou, 2002).

Tregaust (1988, 1995) suggested three stage procedure to develop a valid and reliable two-tier test. In stage 1, content area of the study is defined. In stage 2, students' conceptions are identified based on literature by qualitative analysis. The Stage 3 includes the process of designing test items, and forming final version of test (Chandrasegaran, Tregaust, & Mocerino, 2007). In this study, not exactly the same but a similar way followed as suggested by Tregaust (1988, 1995) in order to develop a diagnostic GCT-II instrument. At stage 1, since the national chemistry curriculum was examined by taking into account instructional objectives (see Appendix A) of gases concepts for GCT-I, researcher decided to use this information for stage 1. Based on the chemistry curriculum, 19 instructional objectives that were frequently encountered by 10th grade students were identified. The subtopics introduced to students in the chemistry syllabus were included in a list of subtopics, namely, properties of gases, gas laws, ideal gas law, kinetic theory of gases, real gases, and gas mixtures (see Appendix B). Moreover, a concept list related to the subject was composed (see Appendix B). Two chemistry professors, one assistant professor, three research assistants in chemistry education and one chemistry teacher reviewed the instructional objectives, list of subtopics and concept list by taking general perspective of gas concepts into account and decided that the covered content area was appropriate and relevant to use for 10th grade students.

At stage 2, semi- structured interviews to determine alternative conceptions that not included in the literature and outcomes of gases concept test as multiple choice test format was used. Interviews were administered to 8 students from 11th grade based on their knowledge level as low, medium and high. Students' knowledge level was determined with respect to their academic achievements in chemistry lesson.

Interview questions were prepared by researcher based on literature about high school students' difficulties about gases concepts in chemistry (see Appendix H for interview questions). Same interview question was used to examine the 10th grade students' conceptual understanding in gases concepts and to clarify students' alternative conceptions in experimental and control groups after the implementation.

Beside the related literature, pilot study results of the GCT-I were taken into consideration in order to develop appropriate interview questions in terms of examining students' alternative questions about gases concepts. During the interviews, responses of students on GCT-I were asked to give reasons in detail on their answers as follow up questions. After analyzing interview responses of students and GCT-I responses, in the development of the second-tier, detected alternative conceptions in GCT-II were included in the alternatives of each item. The second tier was consisted of a correct reason for first tier, and some alternative conceptions derived from the interviews, GCT-I results and related literature. The collected data from first and second stage contributed to construction of first version of GCT-II at the stage 3.

For the face and content validity, six experts in chemistry education analyze and evaluated this test in terms of appropriateness of items in order to assess students' conceptual understanding of gases concepts and to identify students' misconceptions. The experts' suggestions were used to revise the test. Subsequently, 20 two-tiered questions constructed; in the first tier, a multiple-choice question was asked related to instructional objectives includes concepts of gases and in the second tier, the reason of selecting that choice, derived from interviews and GCT-I results, was asked in multiple-choice format. The first content tier had three, four or five choices and the second content tier had five choices. Lastly, the final form of the test was applied to students after the treatment as a part of this study. Table 3.3 presents the alternative conceptions appeared in the test.

Table 3. 3 Alternative conceptions of students

Alternative conceptions	**Items**
1. Hot air weighs less than cold air.	2.2.b
2. Heated air weighs more than cold air.	2.2.d, 8.2.d
3. Pressure acts downward only.	1.2.b, 14.2.c
4. Heated gas weights less.	2.2.b
5. Gases behave ideally at room temperature	9.2.c
6. Misuse of Ideal Gas Law	9.2.a, 9.2.b, 10.2.e, 19.2e
7. Misuse of Charles's law	9.2d, 19.2b
8. Misuse of Boyle's law	4.2.b, 3.2.e, 14.2.a, 19.2a
9. Misuse of Avogadro's law	11.2.d, 11.2.e, 15.2.b, 15.2.c, 19.2d
10. Ideal gases do not give any chemical reactions.	9.2.e
11. The conditions that gases behave ideally depend on the nature of gases.	17.2c
12. Gas molecules do not occupy all the space available in a vessel	10.2.d
13. When heated the molecules expand, when cooled they shrink.	2.2e, 1.2e, 6.2b, 8.2a, 8.2 e
14. Gas particles take the shape of container.	1.2.c, 6.2.c
15. Gases are lighter than liquids so the mass of the substance decreases with change of state from solid to liquid to gas.	6.2.e

Table 3.3 (continued)

16. Molecules increase in size with change of state from solid to liquid to gas.	7.2.d, 6.2.a
17. Gases have no mass.	7.2.b
18. When the air is compressed temperature increases because kinetic energies of the particles increase.	12.2.c
19. Gases behave ideally at low temperature and high pressure.	17.2.d
20. Gases are light. The gases particles weigh very little and therefore rise.	1.2.a
21. Ideal gases do not give any chemical reactions.	9.2e
22. Volume of a gas is the size of the particles.	5.2.b
23. The volumes of different gases are proportional to their particle numbers in a container	5.2.d
24. Attractive forces between gas molecules increases as the temperature decreases.	17.2.d
25. When the air is compressed size of the molecules decreases because of the decrease in volume.	12.2.b
26. Air pressure is greater at higher altitudes.	3.2b, 3.2c, 4.3c, 4.3d
27. Air only exerts force or pressure when it is moving.	13.2.e
28. Gases flow like liquids. This means that they can be unevenly distributed in a container.	1.2.b
29. Gases are able to exert pressure because of the weight of the air above it - because of this air pressure only act down.	13.2.b
30. Molecules were pushed down by the atmospheric pressure.	14.2.e
31. The diffusion rate of a gas is directly related to its molecular weight.	16.2c, 18.2e, 20.2a
32. The diffusion rate of a gas is directly related to its volume.	16.2a, 16.2.e
33. The diffusion rate of a gas is directly related to its mole.	18.2d, 20.2c, 20.2e
34. Temperature is necessary to calculate a gas' partial pressure.	18.2.c
35. Heavy gases occupy more space than the lighter ones.	5.2.b
36. Gas particles have no movement at 0 atm pressure.	17.2.e

The answer of an item was considered to be correct and scored 1 if both first and second tiers were correctly answered. The item was scored 0 if both or either of first and second tiers was wrong (Akkuş, 2011; Chandrasergan et. al., 2007). Totally, there were 20 items in PostGCT. Thus, the maximum score that a student can reach was 20, while the minimum score was 0.

The pilot study was conducted with 92 high school students (45 females, 47 males) to evaluate reliability aspects of this test. Cronbach's alpha reliability of the pilot test was computed as 0.718 for first tier scores and 0.746 for second tier scores. The data give evidence for two-tier test is more reliable than one-tier test. The item analysis was conducted for the GCT-II. The item analysis scores for GCT-II are shown in Table 3.4.

Table 3. 4 The item analysis scores for GCT-II

Item analysis Scores for GCT-II (n=92)	
N. of cases	92
N. of items	20
Cronbach alpha reliability	0.746
Mean	14.839
Median	14
Mode	14
Minimum	0
Maximum	20
N of items with difficulty index(p)	
$.8<p$	1
$.7<p<.8$	6
$.6<p<.7$	4
$.5<p<.6$	2
$.4<p<.5$	6
$.3<p<.4$	0
$p<.2$	1
N of items with discrimination index(D)	
$.7<D<.8$	2
$.6<D<.7$	0
$.5<D<.6$	8
$.4<D<.5$	5
$.3<D<.4$	4
$.2<D<3$	1

Results of item analysis showed the discrimination indices which is the correlation between correct and incorrect responses for each item ranged from 0,333 to 0,777 with an average of 0,563. Item discrimination index was acceptable since it is greater than 0.3 (Lien, 1971 as cited in Chandrasegaran et al., 2007). Only item 15 has lower index which was 0.248 than suggested ranges. Since the discrimination indexes between 0.20 and 0.29 need revisions, item 15 was examined and revised in GCT-II based on results (Crocker & Algina, 1986, p.315). The difficulty indices of the items ranged from 0.245 to 0.870 with an average of 0.549. These results point out that the items were moderately difficult for the high school students and 54.9% of the students gave correct answers for the GCT-II. The final version of GCT-II was administered to both control and experimental groups as post-test.

3.4.3 Attitude Scale toward Chemistry (ASTC)

The ASTC was developed by Geban, Ertepınar, Yılmaz, Altın and Şahbaz (1994) in order to determine students' attitudes toward chemistry as a school subject. This test includes 15 items in which all items were scaled on a 5-point likert type scale from strongly agree to strongly disagree. The Cronbach's alpha reliability coefficient was found to be 0.83 which is above desired value of 0.7, it can be concluded that the reliability of instrument is relatively high. This test was applied to students in both experimental and control groups to measure attitudes towards chemistry before and after the treatment. The ASTC scale includes both positive and negative statements which was included in Appendix F. The negative statements were reversed in the coding process. Hence, ASTC scores were ranged from 15 to 75. The students who have higher scores in ASTC mean he/she has more positive attitudes toward chemistry.

3.4.4 Argumentativeness Scale toward Argumentation

In this study, the argumentativeness scale, developed by Infante and Rancer (1982) was used to as a way of measuring a person's tendency to pursue or avoid of argumentation in argumentative situations. This scale was adapted into Turkish by Kaya (2005). The ASTA is a likert type instrument with five scales and includes 20 items (see Appendix G). The response categories were "absolutely disagree", "disagree", "undecided", "agree", and "absolutely agree". Because the ASTA includes both positive and negative statements, negatively formulated statements were reversed in coding. The maximum score is 100 and the minimum score is 20 for this scale. The reliability of the ASTA was analyzed as Cronbach's alpha value and found as 0.86 for statements pursue an argument and 0.91 for the statements include avoid an argument (Infante & Rancer, 1982, p.76). In this study, the Cronbach's alpha reliability coefficient was found to be 0.71 which is above the suggested alpha value of 0.7 and preferably higher for educational studies (Fraenkel & Wallen, 2003, p.168). The scale was applied only experimental group students before and after the treatment because the implementation of argumentation.

3.4.5 Semi-Structured Interviews

Semi-structured interviews were applied to examine the students' conceptual understanding in gases concepts and to clarify students' alternative conceptions observed in gases concept test. Interviews were conducted with students individually. The interview schedule was constructed by the researcher. The interview questions were prepared according to literature review and common misconceptions found in the literature related to the gases concepts and applied to the students in both experimental (4 students) and control groups (4 students). Beside the related literature, pilot study results of the GCT-I and GCT-II were taken into consideration in order to develop appropriate interview questions. The 7 questions were related to gas properties, distribution of gas particles at different temperatures, diffusion of gases, gas laws, and ideal gases (see Appendix H). The purpose of these interviews was to find out students' ideas about gases concepts and examine students' alternative conceptions.

The students who were interviewed selected purposively based on their knowledge level and their knowledge level was determined with respect to their academic achievements in chemistry lesson. Each interview took about 30 minutes and all of them were audio-taped and transcribed.

3.4.6 Classroom Observation Checklist

The primary purpose of classroom observation was to monitor the application of treatment in the experimental and control group in order to ensure treatment verification. In order to check whether experimental groups took a treatment based ADI instructional model and control group took a treatment based on traditional chemistry instruction or not, an observation checklist designed by the researcher (see Appendix I). The checklist was used for treatment verification.

The researcher monitored all lectures in the experimental and control groups. Moreover, some lessons were observed with two observers who filled the observation checklist in order to avoid the bias of the researcher and obtain more reliable data. During the observation the observation checklist used in this study consisted of 19 items with 3 point likert type scale (yes - 3 / partially - 2/ no - 1).

3.5. Procedure

This part explains the procedure that followed in the current study from beginning to end. Through the study, each step that followed was described below in detail;

- First, the main research problem was determined for this study, which was studying on argumentation based instruction on students understanding of gases concept and determining students' attitudes toward chemistry.
- Key words are determined to be used in the literature review. Keywords used in this study are "argumentation", "scientific argumentation", "Toulmin's argumentation pattern (TAP)", "Argument-Driven Inquiry", "guided inquiry", "science attitude", "alternative conceptions" and "gases concepts".
- During the literature review, the keywords were searched as variety of combinations ERIC, Social Science Citation Index, Wiley InterScience, ProQuest (UMI) Dissertations & Theses, Turkish Higher Education Council National Dissertation Center, METU Library Theses and Dissertations, and TUBITAK Ulakbim databases. While, the researcher reading all of the obtained sources and examining results of the studies, a new instructional model inspired her to study on argumentation-based inquiry which is called Argument-Driven Inquiry. So, literature was reviewed again and main problem of the study was revised after this inspiration. Because literature review is an on-going process, it continued up to end of the study.
- Instruments were developed in order to use the current study (GCT-I, GCT-II). The pilot study of the GCT-I and GCT-II was done before the treatment. Necessary permissions were taken for other instruments (ASTC, ASTA).
- The needed materials for instruction were prepared by the researcher for students and teachers.

- Required permissions were taken from the Ministry of National Education from two regions Çankaya and Yenimahalle in Ankara to conduct the study in high schools. The sample of this study formed by choosing a public high school from the accessible population by using convenience sampling approach. In this high school, six classes of same teacher were participated in this study.
- Pilot study was performed in the 2012-2013 fall semester (December, January) to administer instruments. Two schools were used in Yenimahalle and Çankaya for the administration of tests. Semi-structured interviews were done before the implementation for developing GCT-II instrument.
- Pre-tests of GCT-I, ASTC and ASTA were applied to both experimental and traditional groups on the same day one week before the study.
- Main study was carried out in the 2012-2013 spring semester, in a two 45-minute sessions per week for both of the groups and the treatment was conducted over seven weeks (totally 14 sessions).
- During the study, the topics related to gases were covered as a part of regular classroom curriculum in chemistry course. Six intact classes of same teacher in a public high school were participated in this study. The teacher's three classes were chosen as the experimental group and the other three classes were chosen as the control group. There were totally six groups in this study: three of the groups were experimental groups and the three of them were control groups. The control groups were taught by using traditional chemistry instruction (TCI), while the experimental groups were taught by using ADI instructional model. After the implementation, posttests were applied at the seventh week. Lastly, semi-structured interviews were conducted after two weeks of treatment complementation.
- Data gathered from the pre- posttests were entered to the SPSS. The qualitative data gathered from -interviews were also transcribed.
- Data analysis in terms of descriptive, inferential and confirmatory statistical analysis was performed for the GCT-I, GCT-II, ASTC and ASTA.
- Finally, the dissertation was completed in December 2014.

3.6. Treatments

This study was conducted during seven weeks on gases concepts included in the states of matter unit. Experimental and control groups were assigned to carry out this quasi- experimental study. The control groups were taught by using traditional chemistry instruction (TCI), while the experimental groups were instructed by using ADI instructional method. Lesson plans and activities based on ADI approach was created by taking objectives of the national chemistry curriculum into account by researcher. Some revisions were done on lesson plans and activities based on two professors in chemistry education and two chemistry teachers' feedbacks. Before the implementation, because the chemistry teacher in high school had no experience of implementing ADI in classroom environment, researcher had several meetings with teacher. Before the implementation process, during three weeks researcher inform the teacher how he implement and follow the lesson plans (See Appendix K for sample lesson plan). The researcher also provided the handout about ADI for teachers, activity sheets, lesson plans and materials (such as burette, petri dish, pipe, some chemicals etc.). The experimental group students who were instructed by using ADI instructional model completed 5 investigations during the study. The experimental group students were implemented into the chemistry laboratory. Beside this, in order to make the treatment less novel for control groups, the teacher also conducted chemistry lessons into the laboratory in the most of the weeks.

3.6.1 Treatment in Experimental Group

At beginning of the study, the teacher had no experience of implementing the ADI instructional model. Before the study, during three weeks, the researcher had several meetings with the teacher at school to give information of him about the implementation of ADI. The teacher was given ADI information notes and introduced the ADI instructional model with related activities. Moreover, teacher was supplied a detailed handout that includes the steps of ADI (see Appendix J).The next week teacher read the given materials, lesson plans and the researcher and the teacher examined the activities and talked about the implementation of ADI. Before the lessons, researcher assisted the teacher about the procedure to be followed in the current class during the treatment. The researcher participated in all class sessions and took observation notes.

The experimental group students were implemented into the chemistry laboratory in the most of the weeks. In order to make the treatment less novel, the teacher also conducted most of the chemistry lessons into the laboratory for control groups. There were six benches at the chemistry laboratory and so students formed six groups in each of them for the classroom activities.

At the first week, students were informed about argumentation as a learning tool by an activity named "Babysitter" (see Appendix L). For the babysitter activity, students formed small groups and they were asked to read it individually and choose the most suitable babysitter as a claim for their group, and support their answer with appropriate reasons and evidences about the activity. Then, students shared their claims and reasons to present their findings to classmates. After completing the task, a student from each group wrote their group's answer (the babysitter they choose) on the white board and then each group tried to support their answer with appropriate explanations to the entire class. This step gave students opportunity to evaluate the others' claims and explanations. At the end of the activity, the teacher explained the process in detail from the beginning to the end.

The teacher gave information about the terms of claims, evidence and reasons. This activity's aim was to make students be aware of the process of argumentation, which is a combination of claim, reason and evidence. The next five activities were Diffusion of gases, Gay-Lussac's Law, Charles's Law, Ancient Coin Activity and Boyle's law that utilized all steps of the ADI model. Then the teacher introduced the following week's chemistry topic, diffusion of gases. Firstly, the teacher asked what they know about the properties of gases to elicit students' prior knowledge. The teacher listen students' responses and gave students following week's activity which is about diffusion of gases and want to think about research question in this activity till the following week's chemistry class and share their thoughts within their group, and then offer a procedure within group for the next class. This part also reflects the entrance of the regular steps of ADI instructional model. As a part of study, the ADI instructional model with seven steps was implemented during the current study. The steps were followed are below;

Step 1. This step was designed to introduce the topic and take attention of students (Walker et al., 2012). The students were provided an activity sheet that includes information about the topic and a research question to answer by using given material in the sheet during the laboratory investigation (see Appendix M for activity sheet). The activity sheet also included a material list that could be used during the investigation and some clues or recommendations to help the students when starting the investigation (Sampson et al., 2011). Students were asked to propose an appropriate investigation method to answer the research question. In the first activity, teacher distributed the activity sheet about diffusion of gases and made students to form groups of 4-5. Then, he asked them to read the information and research question about diffusion of gases on the sheet. According to given scenario in the first activity, there were two characters called Selma and Metin who were given a task to label bottles that contain unknown chemicals into the laboratory. In order to complete the task they decided make an experiment by using some additional information provided on the activity sheet. After reading the current research question that is "Which bottled chemical is HCl and which bottled chemical is NH_3?" students were asked to develop a method in order to reach the answer of research question by putting themselves in Selma and Metin's place. At this point, the students were expected to make brainstorming about the solution of the research question and they were asked to suggest a method for laboratory investigation.

Step 2. In the following week, students came to the class with their experiment procedure and wrote them on the white board. At first, students' claims were written on the board without a critical comment. Each group mentioned about the method in order to solve the research question. Perhaps the most difficult part is the first part for students and teachers because students used to follow step-by-step procedure in traditional laboratory courses and teachers used to answer questions directly. So at this step, students needed more guidance to design a method in order to conduct an experiment. In order to provide guidance to high school students, the teacher and whole class evaluated the relevance of each group method with research question and appropriateness for the laboratory investigation. The teacher helped students to think the list of materials on activity sheet as a hint. For example, for the first activity, teacher asked questions such as "Why do we need a glass pipe? What can be measured by the ruler?" Additionally, teacher encouraged students to think about issues they might not have considered. The method to follow for investigation was discussed in the classroom during 15 minutes of the class session. After the developed method was discussed, some revisions were done on some group's methods, and each group participated in the laboratory experiments to answer given research question. During the experimentation, each student was encouraged in order to record their data and observations.

At the beginning of the diffusion of gases laboratory investigation, the teacher wrote the general equation for diffusion of gases (Graham's law) on the board then made some explanations similar with the information on activity sheet. Then, he answered some questions about gases. So, the students understand that they must compare the rate of diffusion of two gases based on their mass. During the process of inquiry in laboratory, the teacher avoided to answer questions directly, instead, he responded with, "Why are you considering that?" When the group suggested inappropriate solutions to find the chemical for the bottles, he acted as a guide and asked different questions. For example, when a group did not see the place of white smoke (NH_4Cl), he suggested them to conduct a new experiment and add more drop of chemicals. He also advised some groups to wait more time for the preparation of NH_4Cl. At this point, the level of inquiry changed in terms of nature of investigation. At the end of these processes, each group wrote their research questions, claims and evidences on the board to share them to entire class.

Step 3. At this step, students constructed argument as a solution of research question that involves explanation supported by evidences and reasons based on their data and observations. At this step, students get started to put together their notes for argumentation session. Each group tried to make an agreement on a claim with appropriate evidences and reasons. Then, each group crafted a claim such as "Bottle 1 contains HCl" as an answer of research question and tried to support their claim with appropriate evidence as empirical data that refers the measurements or observation during investigation process. After discussion in small groups, each groups made an agreement on the answer of research question to share with others. Students also were encouraged to fill the parts of 3, 4 and 5 namely; claim, data and reasons as draft in their investigation reports.

Step 4. After the completion of Step 3, each group had opportunity to share their arguments. They wrote their answers as claims, evidences and reasons on the board and shared the groups' argument with others. A student from each group wrote their groups answer, data and evidence on the white board and explained the group's idea. The aim of this step is to make students' claims, evidence, and reasons noticeable to each other to evaluate each other's arguments (Walker, 2011).

At this point, teacher played as a facilitator role. When groups 'claims were not supported any evidence, teacher tried to make students think and find explanations by asking questions in order to link to their prior knowledge. For instance, when a group only claimed "Bottle 1 contains HCl" and not provide enough support for claim, the teacher asked the students "Why are you considering that" , "What is your evidence?" ,"What is your collected data?" in order to prompt to support their answer. Each group shared their answer for research question and evaluated the validation of other groups' explanations. It means this step gave students an opportunity to evaluate others' explanations, claims, and data to decide which is the most acceptable.

After each group shared their answers, on the one hand students justified their own claims; on the other hand they refuted some elements of arguments claimed by others those are inappropriate for them. For example, at the diffusion of gases activity, group3 claimed "Bottle 1 contains NH_3, because the white smoke, NH_4Cl, is closer the side of bottle 1 which contains NH_3." The other group, group1 claimed that their answer is wrong because the mass of NH_3 is lighter than HCl, NH_4Cl appears nearer the HCl. So, they refuted the group 1's answer and claimed that the bottle 1 contains HCl. In other words, by the help of argumentation session students learned to critique the components of argumentation such as claims, evidences etc. At the end of the whole class discussion teacher made required explanations in order to make students aware of the meaning of claim data and reason words by taking students' explanations into account.

Step 5. In the fifth step of the ADI instructional model, the teacher, asked students produce an investigation report based on ADI instructional model. The aim of this report is to understand the goal of their investigation and learn to write in science. In this study, ADI laboratory report begins with a scenario about gases and required information about the current topic follows it. Namely, the research question, material list and safety rules follows other parts. Actually, all the activity sheets include laboratory report part based on ADI. This report is organized into six parts around six essential questions: Which method did you follow during investigation? What are your observations and data? What is your claim? What are your evidences to support your claim? What is your reason to link between your claim and evidence? Which are your changed ideas?

Aforementioned the first investigation report is about diffusion of gases and it was given students at the beginning of the activity with the research question: Which bottled chemical is HCl, which bottled chemical is NH_3? The teacher explained in detail parts of the report. Students were asked to fill given space under the questions based on ADI instructional model on the activity sheets. They wrote developed method to answer of research question, observations and data during experimentation process such as place of NH_4Cl, calculations of Graham's Law equation, claims such as "Bottle 1 includes HCl", evidence includes their because statements "…because the mass of NH_3 is lighter than HCl, NH_4Cl appears nearer the HCl" as their required data, and reason to support evidence as "…the lighter molecule has the greater speed than the heavier molecule. At the end of the report, students were also wanted to write their changed ideas during the ADI process.

Step 6. At step 6, after completing their investigation report, the teacher randomly distributed the reports of other groups to each other group. With the aim of engagement in the evaluation practices surrounded in the model, students assessed the other groups' reports with a peer review sheet as a part of double blind peer review. The groups reviewed each report and then evaluate whether it needs to be rewrite based on the questions involved on the peer review sheet. The peer review sheet includes a criterion list to evaluate quality of other groups' laboratory reports around three questions: Did the group provide an appropriate claim based on research question? Did the group provide an appropriate evidence to support their claim? Did the group provide an appropriate reason to support their evidence? The peer review sheet was constructed by researcher based on the studies Walker et al., 2011,Walker et al., 2012, and Walker & Sampson, 2013 (see Appendix N for peer review sheet) Each group reviewed the others' report as a team and then decided whether it could be valid or needs to be revised in the light of criterion list. Since the lack of time, sometimes this step was not completed over the study.

Step 7. Lastly, all students were given opportunity to revise their reports based on the comments of other groups. Then, the teacher asked the students bring their final reports in the next week. Once completed, the final form of the reports was submitted by the instructor (see Appendix O for sample student laboratory report).

The students joined to five more laboratory sessions about the gases. For each session, the students followed the similar instructional method. While some lectures completed in two hours, some of them completed more than two hours. Table 3.5 shows the timetable for data collection.

Table 3. 5 Data collection time table

Week	**Activities**	**Data Collected**
1	Introduction of argumentation and ADI instructional model. Babysitter Activity	PreGCT PreASTC PreASTA for experiment group
2	Diffusion of Gases Activity	Lab. Reports, Observation
3	P-T Activity(Gay-Lussac' Law)	Lab. Reports, Observation
4	V-T Activity(Charles's Law)	Lab. Reports, Observation
5	Ancient Coin Activity	Lab. Reports, Observation
6	P-V Activity(Boyle's Law)	Lab. Reports, Observation
7		PostGCT PostASTC PostASTA for experiment group Interviews

3.6.2 Treatment in the Control Group

In control group the traditional chemistry instruction that lectures are predominantly teacher oriented was used. Teacher started the lesson by asking some questions about general properties of gases in order to activate their prior knowledge. The students followed step-by-step procedure for experiment in their book. They made observations and gathered data to analyze without any argumentation process.

During the treatment, after question-answer session, the teacher usually explained the topic, stressed the important points of subject, wrote the key concepts and formulas on the board and students only took notes. When students asked the questions because they did not understand the concept and so far from the real points, the teacher guided them to go real point, made gave extra explanations and sometimes directly gave correct answers. However, the teacher did not try to improve conceptual understanding. The teacher followed the order of the book there is an organization from simple to complex and classification. When the topic covered algorithmic questions, teacher was solved first problems on board and asked similar questions to control students' understanding. In order to answer questions on white board, students raised their hands and teacher call on students who solved problem faster and raised hands. Students wrote the questions and answers to their notebooks. Besides, control group students were also implemented into the chemistry laboratory in order to make the treatment less novel in many weeks.

After the necessary explanations about the topic, teacher gave students the procedure they follow and supplied the materials for them. These traditional chemistry laboratory hours involved step-by-step procedure for analyzing the data. Students made observations and gathered data to analyze without any argumentation process. In addition, teachers asked students produce a laboratory report in their notebooks that includes goal, procedure, materials, observations and related calculations of the current experiment. Students brought their laboratory reports in their notebooks in the next week.

For example, in the first week, the introduction of gas state of matter was started with the teacher's questions about compression and expansion of gases. Then teacher explained the concepts without any molecular representation. After that, teacher asked students consider how to explain diffusion of cologne odor throughout the room if a cologne bottle is opened. It was actually an example of daily life. After some students gave answer and explained their ideas about what they know about diffusion of gases on the teachers' question, the teacher explained the kinetic theory of gases and described the basic concepts in the theory.

Then, teacher wrote on the board the equation of Graham's Law and gave the details about Graham's Law based on the kinetic theory beginning from equality of kinetic energy of two different gases at the same temperature. After the necessary explanations about the topic, teacher gave students the procedure they follow to conduct an experiment about diffusion of gases and supplied the materials for them. The first experiment was similar with experimental groups' experiment and included the diffusion of two gases; HCl and NH_3' from opposite ends of a long tube. Students observed when these two gases meet and react they produce ammonium chloride, a white solid powder. Since students used to follow step-by-step procedure in traditional laboratory courses, this part was easier for teacher and students when compared ADI instructional model laboratory experience. When students asked questions, teacher answered questions directly and sometimes helped their experiments. After completion of experiments of each group, teacher want to students to write the goal, procedure, materials, observations and related calculations of the current experiment on their notebooks in the form of a laboratory report. Students brought their laboratory reports in the next week.

3.7 Data Analysis

The software of SPSS was used for the data obtained through application of the GCT-I, GCT-II, ASTC and ASTA as pretest and posttest. The gathered data from pre-posttests of GCT-I, GCT-II, ASTC and ASTA were entered into Microsoft Excel. Then, each student's score from these tests were computed and then the scores were converted to the SPSS.

Moreover, other variables which are students' gender, class, and group membership were also entered to this SPSS file. The descriptive statistics was conducted for each variable and presented as scores of experimental and control groups' mean, standard deviation, skewness, kurtosis, minimum, and maximum values.

For the inferential statistics, multivariate analysis of covariance (MANCOVA) was conducted with two dependent variables, which were PostGCT and PostASTC; two independent variables, which were treatment and gender; and one covariate, which was PreASTC. Since the aim was to generalize results obtained from the sample to the population, MANCOVA was also appropriate. Furthermore, because the ADI instructional model was implemented only in experimental group students, paired sample t-test was used to experimental groups' scores on PreASTA and PostASTA. Also, missing data was checked and variables and subjects were inspected in terms of missing values.

Before conducting MANCOVA, all variables were checked for assumptions of MANCOVA, which were normality, outliers, multicollinearity, homogeneity of variances, homogeneity of regression, and independence of observations and all assumptions was met.

3.8 Power Analysis

Effect size for this study was set to medium effect size of 0.15 measured by f^2 (Cohen & Cohen, 1983) by taking into account the results of previous research. Probability of making Type 1 error which refers probability of rejecting a true null hypothesis, α was also set to .05 and probability of making Type 2 error which refers probability of failing to reject a false null hypothesis, β was set to 0.2. Thus, the power of the study (1- β), probability of rejecting a false null hypothesis, was set to 0.80 (Cohen, Cohen, West & Aiken, 2003).

In order to calculate the necessary sample size, the formula ($n=L/f^2 + ka + kb + 1$) for Model 1 was used (Cohen et al., 2003, p.181). First, ka (number of covariates) and kb (number of fixed factors -1) were determined. The value of ka is number of covariates and it is 1 for this study (PreASTC). The kb value was found as 1 by subtracting 1 from levels of fixed factors which is teaching method and it has two levels (n) which are experimental and control groups.(kb = n-1= 2-1=1). The "L" value was read as 7.85 for α=0.05, power=0.80 from the L table (Cohen et al., 2003, p.651) for this study. Hence, the necessary sample size was calculated as 55 (7.85/0.15+1+1+1=55).

In this study data was gathered from with 157 students. Since the L value was calculated as 23.1, the calculated power was greater than 0.99 in the L table (Cohen et al., 2003, p.651).

3.9 Unit of Analysis

In this study, each individual indicates the unit of analysis. Although, it is supposed that unit of analysis and experimental unit would be the same, this is not always possible for experimental studies. Since, it was impossible to give treatment to the individuals, experimental unit of the study was determined as each intact class to which treatment was given for this study.

During the treatment, as it was expected, many interactions occurred among individual students. So, it is difficult to claim independence of observations was met during the treatment for this study. However, during the data collection procedure, students were not allowed to interact with each other. Thus, the independence of observation was met during the data collection process.

3.10 Treatment Fidelity and Verification

Treatment fidelity refers the methodological strategies used to monitor and enhance the consistency of a behavioral intervention in order to check it is implemented as planned (Smith, Daunic & Taylor, 2007). In order to enhance the treatment fidelity, first the definitions of Argument-Driven Inquiry instructional model and traditional chemistry instruction were done clearly in terms of literature review. Secondly, instructional materials developed by the researcher were revised by three experts in chemistry education and supervisor of the study to check whether they were consistent with ADI or not. In the light of recommendations, some modifications were done. Several meetings were done with the teacher at school to give information about the implementation of ADI. Moreover, a teacher handout was prepared to guide the implementation of ADI treatment during process of teacher training.

Treatment verification refers whether the treatment was implemented as planned during the study. In this study, to ensure treatment verification, classroom observation check list was used during implementation (see Appendix I). This observation check list consisted of 19 items with 3 point likert type scale (yes - 3 / partially - 2/ no - 1). The researcher monitored all lessons in the experimental and control groups. Moreover, some lessons were observed with two observers who filled the observation checklist in order to avoid the bias of the researcher and obtain more reliable data. The observation check lists were rated by researcher and sometimes observer for each lesson. When the rated checklists were compared, it was concluded that implementation of ADI was appropriate and teacher followed each steps of ADI. During the observation of implementation, researcher also took notes when find it necessary. Moreover, researcher used student investigation reports and those notes that she took in order to check experimental and control group's implementation process and decided treatment was implemented as intended during the study.

3.11 Assumptions and Limitations

The assumptions for the current study were stated below:

- The students responded all instruments honestly, independently and seriously.
- All the instruments were administered under standard conditions.
- The teacher was not biased towards any of instructions.
- Independence of observations was satisfied.

The limitations of the study were stated below:

- The study is limited to 157 10th grade public high school students in the center of the city.
- The study is limited to the gases subject in chemistry curriculum.
- The treatment time was not sufficient for the ADI groups in some weeks.
- Multiple-choice tests were used to evaluate students' conceptual understanding in chemistry.

CHAPTER 4

RESULTS

This chapter covers the results of the study with the following sections: missing data analysis, descriptive statistics, inferential statistics, assumptions of MANCOVA, results of MANCOVA and follow-up ANCOVA, results of students' interviews, results of the classroom observation checklist, and summary of the findings.

4.1 Missing Data Analysis

Prior to the descriptive statistics and inferential statistics, missing data analyses were done. There were missing data in PreGCT, PreASTC and PreASTA, and PostGCT and PostASTC and PostASTA. The students who were missing in at least two dependent variables among PostGCT and PostASTC and PostASTA were excluded from the data set. Thus, 6 students were excluded listwise and 157 students remained for the further analyses. After excluding the students' absent scores, the other missing values of variables are presented in Table 4.1.

Table 4. 1 Missing data analysis after excluding listwise

		PreGCT	PostGCT	PreASTC	PostASTC	PreASTA	PostASTA
	Valid	155	151	154	151	81	81
N	Missing	2	6	3	6	1	1
	Missing (%)	1,2	3,9	3,1	3,9	1,2	1,2

The percentages of missing values were range between 1-5% for all variables. Rates of missing data are generally considered 1-5% manageable (Acuna & Rodrigez, 2000). Since the missing values do not exceed 5% of the whole data, they were replaced with the mean values and new data sheet was used during the statistical analyses.

4.2. Descriptive Statistics

Table 4.2 shows the descriptive statistics with excluded scores about PreGCT, PreASTC, PostGCT and PostASTC for experimental and control groups and PreASTA and PostASTA for only experimental groups. The PreGCT and PreASTC scores were almost the same for the both groups before implementation (see Table 4.2). The possible maximum score for PreGCT was 20, and highest score was 18 for EG and 17 for CG. These scores seem to be high for a pre-test. However, this is because students had been taught about the concepts of properties of gases and fundamental gas laws from the first years of middle school as a part of science and technology classes to the high school years. It means tenth grade students had some pre-existing knowledge about these concepts before the implementation and they got higher scores for this test. Aforementioned, scores of this test were used to compare whether students have difference for previous learning in means of conceptual understanding of gases in ADI and TCI groups.

Although, the mean scores of Experimental Group (EG) and Control Group (CG) in pretests are almost the same in both PreGCT and PreASTC; PostGCT and PostASTC indicates that the total mean scores of posttests (13,39 for PreGCT and 49,77 for PreASTC) are higher than the pretests scores (11,64 for PreGCT and 45,24 for PreASTC). While the mean scores of CG and EG in PostGCT(EG:14,26; CG:12,52) and PostASTC(EG:51,5; CG:48,05) is higher than the ones in PreGCT (EG:11,56; CG:11,72) and PreASTC(EG:45,45; CG:45,04) scores, the amount of raise in EG is much higher than the CG. Whereas the mean of the EG in PreGCT is a bit lower than the CG, the Table 4.2 shows that the mean of EG becomes higher than the CG in PostGCT. That also shows us that the Argument-Driven Inquiry instructional model works well for the benefit of the students.

Table 4. 2 Descriptive Statistics for the variables

	N	Min	Max	Mean	SD	Skewness	Kurtosis
PreGCT							
CG	75	7	18	11,720	2,0896	-0,119	0,476
EG	81	7	17	11,561	2,325	-0,034	-0.316
Total	156	7	18	11,640	2,207	-0,076	0,080
PostGCT							
CG	75	8	16	12,520	2,152	-0,388	-0,373
EG	81	8	19	14,268	2,244	-0,566	-0,273
Total	156	8	19	13,394	2,198	-0,477	-0,323
PreASTC							
CG	75	21	65	45,040	10,003	-0,379	-0,209
EG	81	24	75	45,451	9,333	0,453	0,402
Total	156	21	75	45,245	9,668	0,271	0,537
PostASTC							
CG	75	21	75	48,053	11,074	-0,220	0,084
EG	81	33	75	51,500	8,946	0,496	0,275
Total	156	21	75	49,776	10,010	0,138	0,179
Pre-Post ASTA							
PreASTA	81	40	82	59,703	9,892	0,267	0,529
PostASTA	81	43	95	71,925	12,235	0,228	0,555
Total	81	40	95	65,814	11,063	0,247	0,542

When the PostASTC scores of students examined, the difference between the scores was found in favor of the experimental group since the mean score of EG(52.31) is higher than CG (46.15) with regard to attitude toward chemistry(see Table 4.2) This result showed that experimental group students revealed more positive attitudes toward chemistry than control group students. The possible maximum score of the ASTC is 75 and the possible minimum score is 15. Although the maximum scores did not change in ASTC of EG (75), the minimum score became higher (from 24 to 33) for ASTC scores of experimental group and therefore the average of the test gets high.

In terms of ASTA scores which was applied only experimental group students because the implementation of argumentation, there were significant differences between the PreASTA and the PostASTA scores of experimental groups (see Table 4.2). There was an increase in students' tendency to pursuit of argumentation from PreASTA (59.703) to PostASTA (71.925) scores. In addition, the possible maximum score of the ASTA is 100 and the possible minimum score is 20. The maximum scores were increased from 82 to 95 for ASTC scores of EG after the implementation. In other words experimental group students revealed higher tendency to pursue of argumentation in the chemistry context when compared the beginning of the study.

While the mean scores of PostGCT were examined it was seen from the Table 4.3 that the mean value of CG in first tier is 5.886. When the reason of selecting first tier of the questions was asked in the second tier, the rate of correct response increased to 6.62. That is to say, it rises almost by 13% (0.73 points increase). This inferred that students were able to give correct explanations when they were given appropriate reasons as a result of first tier of the questions. On the other hand, the mean of the EG in the first tier is 6.384, in the second tier it upswings to 7.884. Namely, its growing rises nearly by 24% (1.5 points increase). The maximum score was 9 for the experimental and 8 for the control group in terms of the first tier PostGCT. The maximum score was 12 for the experimental and 10 for the control group in terms of second tier of PostGCT.

Table 4. 3 Descriptive statistics for one-tier and two-tier questions

PostGCT	N	Min	Max	Mean	SD	Skewness	Kurtosis
First-tier							
CG	75	4	8	5,886	1,113	0,277	0,548
EG	82	3	9	6,381	1,320	0,266	0,526
Total	157	3	9	6,135	1,216	0,271	0,537
Second-tier							
CG	75	3	10	6,620	1,423	0,277	0,528
EG	82	5	12	7,884	1,334	0,266	0,403
Total	157	5	12	7,252	1,378	0,543	0,465

The skewness and kurtosis values were in range between -2 and +2, it could be concluded that the PreGCT, PreASTC, PreASTA, PostGCT, PostASTC and PostASTA scores were normally distributed for the experimental and control groups.

4.3. Inferential Statistics

In this section, determination of covariates, assumptions of MANCOVA, results of MANCOVA, and results of follow-up ANCOVA analysis are included.

4.3.1 Determination of Covariates

In order to find covariates first an independent sample t- test for possible covariates PreGCT and PreASTC was performed. Then correlations among all variables were computed.

Table 4. 4 Independent samples t-tests for PreGCT and PreASTC

	Equal Variances	Levene's Test		T-Test for Equality of Means	
		F	Sig.	df	Sig.(2 tailed)
PreGCT	Assumed	1,243	0,267	155	0,654
	Not-Assumed			154,954	0,652
PreASTC	Assumed	0,265	0,608	155	0,79
	Not-Assumed			151,19	0,791

Levene's test was not significant for PreGCT and PreASTC (Table 4.4). So, variances of scores for groups are equal. There was not found any significant mean difference ($t(155)=-0.226$, $p>0.05$) between the EG and CG in terms of students' understandings of gases concepts and attitudes toward chemistry($t(155)=0.449$, $p>0.05$). Based upon this result, it was concluded that pre-tests scores are not required to use as a covariate to control pre- existing differences.

Although there were no significant mean difference or PreGCT and PreASTC scores according to Levene's test, as a second step, to be sure correlations among all variables were computed.

According to Table 4.5, the PreASTC has significant correlation with at least one of the dependent variables. Table 4.5 shows the correlations among independent and dependent variables. Hence, this independent variable (PreASTC) can be used as a covariate for inferential statistics of the study.

Table 4. 5 Correlations among variables

	PreGCT	**PostGCT**	**PreASTC**	**PostASTC**
PreGCT	1	0,052	0,054	0,078
PostGCT	0,052	1	0,092	0,161*
PreASTC	0,054	0,092	1	0,693**
PostASTC	0,078	0,161*	0,693**	1

* Correlation is significant at the 0.05 level (2-tailed) **Correlation is significant at the 0.01 level (2-tailed)

4.3.2 Assumptions of MANCOVA

There are five assumptions in Multivariate Analysis of Covariance (MANCOVA); these are independence of observations, normality, homogeneity of variances, multicollinearity, and homogeneity of regression. These assumptions were analyzed in the following sections.

4.3.2.1 Independence of Observations

In order to verify this assumption, the researcher observed all measurement sessions during administration of instruments whether there were any interactions among individuals. It was ensured that the students accomplished the tests independently and there was not any interaction between students during the administration of the tests. Hence, it was concluded the independence of observation assumption was met for this current study.

4.3.2.2 Normality

To check univariate normality assumption for these variables, Shapiro-Wilk test was conducted. According to table 4.6 PreASTC, PostASTC and PreGCT scores of the students are normally distributed (p>0.05). However, the null hypothesis was rejected for PostGCT scores of students from EG and CG and PreGCT scores of students from CG.

Table 4. 6 Results of Shapiro-Wilk's test

		Shapiro-Wilk		
		Statistic	df	Sig.
PostGCT	CG	,947	75	,004
	EG	,930	82	,000
PostASTC	CG	,978	75	,212
	EG	,975	82	,114
PreASTC	CG	,976	75	,161
	EG	,977	82	,137
PreGCT	CG	,961	75	,020
	EG	,974	82	,094

As a second step for normality assumption, skewness and kurtosis values were checked. The skewness and kurtosis values of all tests fall between -2 and +2 which are acceptable values for the univariate normality normal distribution (George & Mallery, 2003, pp.98-99). So, it can be concluded that normality assumption was satisfied (see Table 4.2).

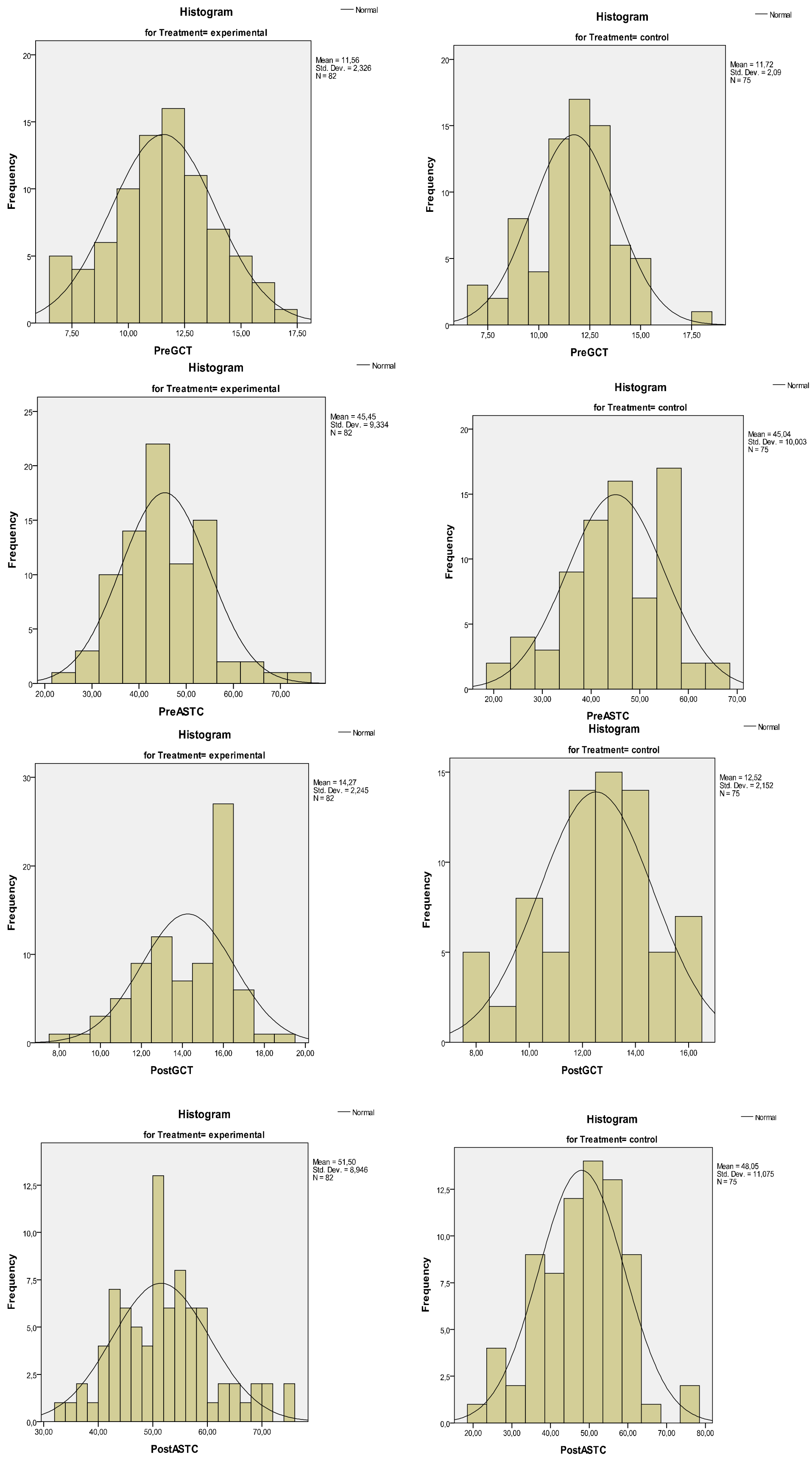


Figure 4. 1 The histograms with normal curves for the PreASTC, PostASTC and PreGCT and PostGCT for experimental and control groups.

Although there are exceptions, this exceptions could be tolerated because the sample size of study is considerably high(George & Mallery, 2003, pp.98-99).Moreover, as an evidence of normal distribution; Figure 4.1 displays the histograms with normal curves for the PreASTC, PostASTC and PreGCT and PostGCT for both the experimental and control groups. Since the curves seem as normal, these histograms can be used as an evidence for normal distribution. In addition, in order to test the null hypothesis 10, a paired sample t-test will be used to experimental groups' scores on pre-post ASTA. All assumptions of paired sample t-test are included in MANCOVA assumptions. In order to support the evidence of normal distribution for pre and PostASTA, Figure 4.2 shows the histograms with normal curves for the PreASTA and PostASTA for experimental groups.

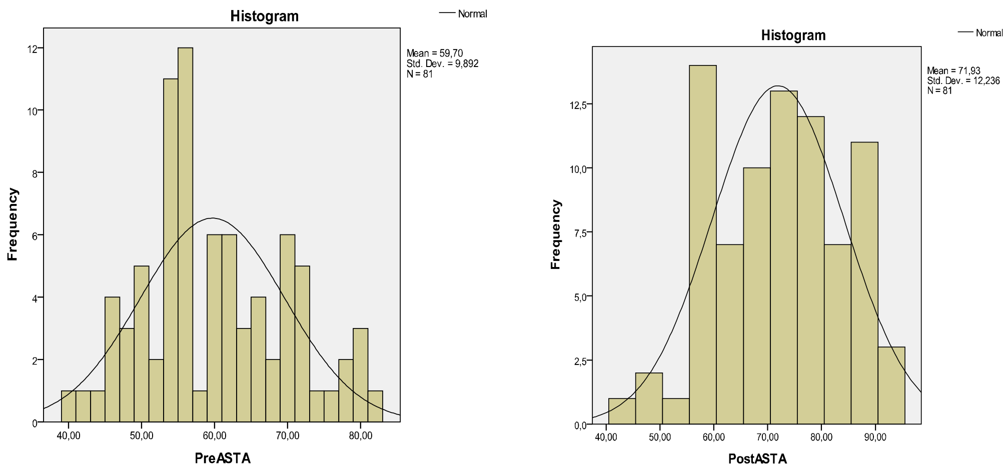


Figure 4. 2 The histograms with normal curves for the PreASTA and PostASTA for experimental groups.

In addition, multivariate normality can be confirmed by using Box's test. Since the p value is smaller than 0.05, multivariate normality assumption was violated (see Table 4.7). Tabachinck and Fidell (2001) recommended Pillai's Trace index, since Pillai's Trace index is more vigorous against violation of the homogeneity of covariance assumption. Hence, Pillai's Trace index was used to read the MANCOVA results.

Table 4. 7 Box’s test of equality of covariance matrices

Box's M	21,518
F	2,331
df1	9
df2	155399,141
Sig.	0,013

Table 4. 8 Residuals statistics for multivariate normality

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	29,6264	135,2265	79,0000	17,00415	157
Std. Predicted Value	-2,904	3,307	,000	1,000	157
Standard Error of Predicted Value	3,447	11,999	5,580	1,816	157
Adjusted Predicted Value	28,3171	135,6806	78,9683	17,19247	157
Residual	-100,98122	85,47233	,00000	42,16664	157
Std. Residual	-2,379	2,014	,000	,994	157
Stud. Residual	-2,437	2,060	,000	1,003	157
Deleted Residual	-105,94900	89,44390	,03174	43,00650	157
Stud. Deleted Residual	-2,478	2,082	,000	1,008	157
Mahal. Distance	,036	11,477	1,987	2,111	157
Cook's Distance	,000	,097	,007	,013	157
Centered Leverage Value	,000	,074	,013	,014	157

MANOVA is very sensitive to outliers. So, multivariate outliers were checked for multivariate normality. Mahalanobis distance was used to check multivariate outliers.

The maximum value of Mahalanobis distance was found as 11.47 (Table 4.8). Hence It was smaller than critical value for two dependent variables (13.82), it was concluded that there was not any multivariate outliers in the data (Tabanick & Fidell, 1996, p.67). Therefore, assumption of outlier was met.

4.3.2.3 Multicollinearity and Singularity

MANOVA gives best results when the dependent variables are moderately correlated (Pallant, 2006). Multicollinearity is known as high correlation among dependent variables. Correlations among dependent variables were examined to check this assumption. As indicated in Table 4.2 all correlations between dependent variables are less than 0.80. As a result, the assumption of multicollinearity is verified.

4.3.2.4 Homogeneity of variances

In order to check whether the error variances across groups are equal, Levene's test was used. Based upon the Table 4.9, ever since this test is not significant($p>0.05$), equality of variances assumption was satisfied.

Table 4. 9 Levene's test of equality of error variances

	F	df1	df2	Sig.
PostGCT	0,595	1	155	0,441
PostASTC	0,512	1	155	0,475

4.3.2.5 Homogeneity of regression

The assumption of homogeneity of regression was checked through the use of MANCOVA in order to test the interactions between the covariates and independent variables (Pallant, 2001, p.241).

Table 4. 10 Multivariate tests for homogeneity of regression for the interaction

Effect		F	Hypothesis df	Sig.	Partial Eta Squared	Observed Power[b]
Treatment * Gender	Pillai's Trace	,503[a]	2.000	,606	,009	,131
	Wilks' Lambda	,503[a]	2.000	,606	,009	,131
	Hotelling's Trace	,503[a]	2.000	,606	,009	,131
	Roy's Largest Root	,503[a]	2.000	,606	,009	,131
Treatment * PreGCT	Pillai's Trace	1.698	16.000	,048	,106	,921
	Wilks' Lambda	1,690[a]	16.000	,050	,107	,920
	Hotelling's Trace	1.682	16.000	,051	,107	,918
	Roy's Largest Root	2,187[c]	8.000	,033	,133	,839
Treatment *PreASTC	Pillai's Trace	7,631[a]	2.000	,001	,119	,942
	Wilks' Lambda	7,631[a]	2.000	,001	,119	,942
	Hotelling's Trace	7,631[a]	2.000	,001	,119	,942
	Roy's Largest Root	7,631[a]	2.000	,001	,119	,942
Gender * PreGCT	Pillai's Trace	,912	16.000	,556	,060	,615
	Wilks' Lambda	,917[a]	16.000	,550	,061	,618
	Hotelling's Trace	,922	16.000	,545	,062	,620
	Roy's Largest Root	1,566[c]	8.000	,143	,099	,672
Gender * PreASTC	Pillai's Trace	,653[a]	2.000	,523	,011	,157
	Wilks' Lambda	,653[a]	2.000	,523	,011	,157
	Hotelling's Trace	,653[a]	2.000	,523	,011	,157
	Roy's Largest Root	,653[a]	2.000	,523	,011	,157
Treatment * Gender * PreASTC	Pillai's Trace	,181[a]	2.000	,834	,003	,078
	Wilks' Lambda	,181[a]	2.000	,834	,003	,078
	Hotelling's Trace	,181[a]	2.000	,834	,003	,078
	Roy's Largest Root	,181[a]	2.000	,834	,003	,078
Treatment * Gender * PreGCT	Pillai's Trace	,998	14.000	,456	,058	,623
	Wilks' Lambda	1,002[a]	14.000	,452	,058	,625
	Hotelling's Trace	1.006	14.000	,448	,059	,628
	Roy's Largest Root	1,701[c]	7.000	,116	,095	,674

The dependent variables (PostGCT and PostASTC) were placed in the dependent variable box, the independent variables (Treatment and Gender) were placed in the fixed factors box, and the covariate (PreASTC) were placed in the covariates box. After all, model and custom selections were functioned. Meanwhile, the all significance values for the interactions were bigger than 0.05, the assumption of homogeneity of regression was satisfied (see Table 4.10). However, the interaction effect of treatment with PreASTC is found significant (p=0.001). Because of the verification of assumption for the other dependent variables, it was concluded that it is confident to continue with MANCOVA analysis.

4.4 Results of MANCOVA

The main problem of the study was to investigate the effects of Argument-Driven Inquiry (ADI) instructional model in comparison to traditional chemistry instruction (TCI) and gender on students' understanding in the gases concepts and attitudes towards chemistry.

In order to make explanation and support with evidence, the main problem and the following null hypothesis of the study were tested.

4.4.1 Null Hypothesis 1

The first null hypothesis was "There is no statistically significant main effect of treatment (Argument-Driven Inquiry instructional model (ADI) and traditional chemistry instruction (TCI)) on the population mean of collective dependent variables of 10th grade students' posttest scores of understanding of gases concepts and their attitude toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled."

In order to test this null hypothesis MANCOVA was conducted. The results of MANCOVA are given in Table 4.11. In this table, MANCOVA analysis indicates that there is a significant mean difference (Pillai's Trace=0.165; F(2, 149)=14.774; p=0.000) between Argument-Driven Inquiry instructional model and traditional chemistry instruction on the collective dependent variables of the PostGCT and PostASTC between groups when the PreASTC was controlled. Hence, the first null hypothesis was rejected. In other words, there was a statistically significant difference between ADI instructional model and TCI on the collective dependent variable in favor of the experimental group. The value of the Partial eta square was found to be .165. In other words, %16, 5 of the multivariate variances in the dependent variables is explained by the treatment. The effect size of the study indicates a large effect size (Cohen, 1988).

Table 4. 11 Results of MANCOVA

Effect	Pillai's Trace	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Intercept	,392	48,023[a]	2.000	149.000	,000	,392	96.046	1.000
PreGCT	,009	,656[a]	2.000	149.000	,520	,009	1.312	,159
PreASTC	,481	69,166[a]	2.000	149.000	,000	,481	138.332	1.000
Gender	,002	,160[a]	2.000	149.000	,852	,002	,321	,074
Treatment	,165	14,774[a]	2.000	149.000	,000	,165	29.547	,999
Gender * Treatment	,019	1,444[a]	2.000	149.000	,239	,019	2.888	,305

Effect size was set to as a medium effect (0.15) for this study. As seen from the table, the calculated effect size of the study is, 0.165 and this value are higher than moderate effect size. The observed power of the study in terms of treatment is 0.999 and it is higher than the calculated power (0.80) at the beginning of the study.

4.4.2 Null Hypothesis 2

The second null hypothesis was: "There is no statistically significant main effect of gender on the population mean of collective dependent variables of 10th grade students' posttest scores of understanding of gases concepts and their attitude toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled".

For the second hypothesis, MANCOVA results were also used to investigate whether there is any statistically significant mean difference between females and males in terms of PostGCT and PostASTC scores. MANCOVA analysis shows that there is not any significant mean difference (Pillai's Trace=0.002; F (2, 149) =0.160;

p=0.852) between females and males in terms of PostGCT and PostASTC scores. Therefore, second null hypothesis was accepted. This result showed that females and males had equal understanding of gas concepts and attitude toward chemistry regardless treatment.

4.4.3 Null Hypothesis 3

The third null hypothesis was: "There is no statistically significant effect of interaction between treatment (Argument-Driven Inquiry instructional model (ADI) and traditional chemistry instruction) and gender on the population mean of collective dependent variables of 10th grade students' posttest scores of understanding of gases concepts and their attitude toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled".

According to the results of MANOVA, as seen from Table 4.11, there was not any statistically significant interaction between the treatment and gender on the PostGCT and PostASTC scores (Pillai's Trace =0.019, F(2,149)=1.444, p=0. 239). Therefore, the null hypothesis was accepted. This result indicates that ADI model did not make any difference in males and females understanding of gas concepts and attitude toward chemistry over traditional chemistry instruction.

4.4.4 Null Hypothesis 4

The fourth null hypothesis was: "There is no statistically significant mean difference between the effects of Argument-Driven Inquiry instructional model (ADI) and traditional chemistry instruction on students' posttest scores of understanding of gases concepts when the effects of attitude toward chemistry pre-test scores are controlled". A follow-up ANCOVA was conducted after MANCOVA in order to determine the effect of treatment on each dependent variable.

Each hypothesis was tested at the p<0.025 level because of the performing test for two different dependent variables.

As seen from Table 4.12, there is a statistically significant difference (F=24.67; p=0.00) between posttest mean scores of tenth grade students who thought by ADI model and those who thought by traditional chemistry instruction on the population means of the gas concepts posttest scores when the effects of gas concepts pretest scores are controlled. Therefore, the fourth null hypothesis was rejected.

Table 4. 12 Follow-up ANCOVA for each dependent variable

Dependent Variable	Source	Df	F	Sig.	Partial Eta Squared	Observed Power[b]
PostGCT	Corrected Model	4	6,420	,000	,145	,989
	Intercept	1	170,431	,000	,530	1,000
	Treatment	1	24,673	,000	,140	,999
	Gender	1	,070	,792	,000	,058
	Treatment*Gender	1	,203	,653	,001	,073
PostASTC	Corrected Model	4	39,704	,000	,513	1,000
	Intercept	1	39,558	,000	,208	1,000
	Treatment	1	6,401	,012	,041	,710
	Gender	1	,242	,623	,002	,078
	Treatment*Gender	1	2,468	,118	,016	,345

When the PostGCT scores of students examined, the difference between the scores is in favor of the experimental group since the mean score of EG (14.27) is higher than CG (12.52) with regard to understanding of gas concepts (see Table 4.13). The value of the Partial eta square was found to be 0.14 for PostGCT. Eta squared was also calculated as 0.14; which indicates a large effect size (Tabachnick & Fidell, 2001, p.369). So, the treatment explains 14 % of the variability of students PostGCT scores. The observed power in terms of treatment was found as 0.99.

Table 4. 13 Estimated marginal means for the PostGCT scores in terms of treatment

Dependent Variable	Treatment	Mean	Std. Error	95% Confidence Interval Lower Bound	Higher Bound
PostGCT	EG	14.27	.248	13.77	14.76
	CG	12.52	.248	12.02	13.01

4.4.5 Null Hypothesis 5

The fifth null hypothesis was "There is no statistically significant mean difference between males and females in students' posttest scores of understanding of gases concepts when the effects of attitude toward chemistry pre-test scores are controlled."

In the table 4.12, ANCOVA results indicated that mean PostGCT scores of females and males do not differ significantly when the effects of students' PreGCT scores are controlled (F=0.070, p=0.792).

Table 4. 14 Estimated marginal means for the PostGCT scores in terms of gender

Dependent Variable	Gender	Mean	Std. Error	95% Confidence Interval Lower Bound	Higher Bound
PostGCT	Male	13.57	.263	13.02	14.12
	Female	13.31	.274	12.78	13.83

As seen from the Table 4.14, PostGCT scores were calculated as 13.31 for females and 13.57 for males. According to the results, the difference in these estimated mean scores was not statistically significant, so the null hypothesis 5 was accepted.

4.4.6 Null Hypothesis 6

The sixth null hypothesis was "There is no statistically significant effect of interaction between gender and treatment with respect to students' posttest scores of understanding of gases concepts when the effects of attitude toward chemistry pre-test scores are controlled".

There was not found any significant interaction between treatment and gender on students' PostGCT scores (F=0.2031, p=0.653). Therefore, this null hypothesis was accepted. Figure 4.3 shows an overview for PostGCT in terms of interaction between gender and treatment.

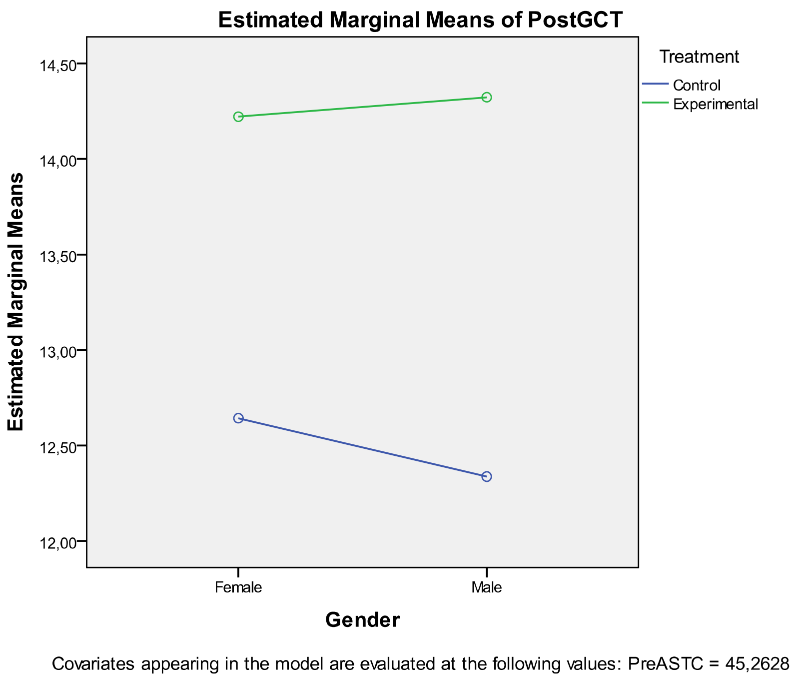


Figure 4. 3 Interaction between treatment and gender with regard to PostGCT

4.4.7 Null Hypothesis 7

The seventh null hypothesis was "There is no statistically significant mean difference between the effects of Argument-Driven Inquiry instructional model (ADI) and traditional chemistry instruction on students' post-test scores of attitudes toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled".

As seen from Table 4.12, there is a statistically significant mean difference (F=6.401, p=0.012) between posttest mean scores of tenth grade students who thought by ADI model and those who thought by traditional instruction on the population means of the PostASTC scores when the effects of PreASTC scores are controlled. Therefore, the seventh null hypothesis was rejected.

Table 4. 15 Estimated marginal means for the PostASTC scores in terms of treatment

Dependent Variable	Treatment	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Higher Bound
PostASTC	EG	52.31	.987	49.53	53.46
	CG	46.15	1.278	45.50	50.60

When the PostASTC scores of students examined, the difference between the scores was found in favor of the experimental group since the mean score of EG (52.31) is significantly higher than CG (46.15) with regard to attitude toward chemistry (see Table 4.15). This result implied that experimental group students seem to develop more positive attitudes toward chemistry than control group students.

The value of the Partial eta square was found to be 0.041 for PostASTC. Eta squared was also calculated as 0.022. So, the treatment explains 2.2 % of the variability of students PostASTC scores. The observed power in terms of treatment was found as 0.71.

4.4.8 Null Hypothesis 8

The eighth null hypothesis was "There is no statistically significant mean difference between males and females with respect to students' posttest scores of attitudes toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled".

The conducted follow-up ANCOVA investigated this null hypothesis (Table 4.12). There was not found significant mean difference (F=0.242, p=0.653) between PostASTC scores of females and males when the effects of students' PreASTC scores are controlled. Therefore, this null hypothesis was accepted.

When the PostASTC scores of students were examined, the difference between the scores was found in favor of the males since the mean score of males (50.07) is slightly higher than females (48.81) with regard to attitude toward chemistry (see Table 4.16).

Table 4. 16 Estimated marginal means for the PostASTC scores in terms of treatment

Dependent Variable	Gender	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Higher Bound
PostASTC	Male	50.07	1.14	48.68	52.26
	Female	48.81	1.15	46.53	51.10

4.4.9 Null Hypothesis 9

The null hypothesis nine was "There is no statistically significant effect of interaction between gender and treatment with respect to students' posttest scores of attitude toward chemistry when the effects of attitude toward chemistry pre-test scores are controlled."

There was not found any interaction between treatment and gender on students' attitudes toward chemistry (F=2.468, p=0.118). Therefore, this null hypothesis was accepted. Figure 4.4 gives an general idea for PostASTC in terms of interaction between gender and treatment.

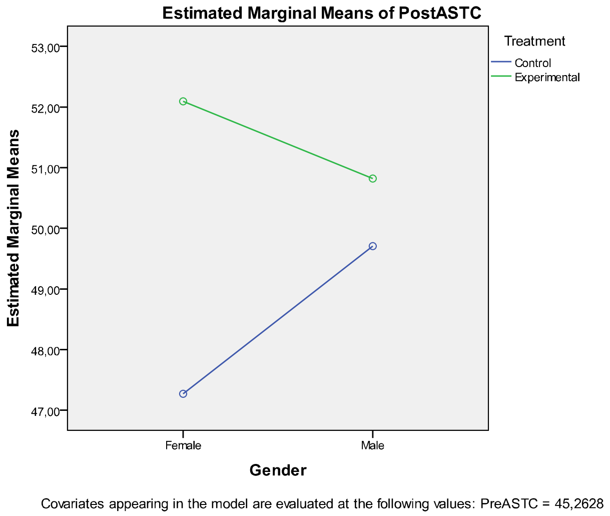


Figure 4. 4 Interaction between treatment and gender with regard to PostASTC

4.4.10 Null hypothesis 10

The null hypothesis 10 was "There is no statistically significant mean difference between the post-test scores and pre-test scores of students taught by Argument-Driven Inquiry instructional model (ADI) on the population means of tendency of argumentation."

The paired-samples test was conducted to investigate the effect of ADI model on students' scores on the ASTA in terms of tendency of argumentation. There was a statistically significant increase in students' tendency of argumentation from PreASTA(59.703) to PostASTA(71.925) scores (t(80)=11.826, p=0.000).Therefore, the null hypothesis was rejected(see Table 4.17). This result implied that there is a significant increase of students' who taught ADI instructional willingness to pursue of argumentation.

Moreover, effect size was calculated as 0.642; so it was concluded that there was a large effect in terms of tendency of argumentation scores obtained from PreASTA and PostASTA. According to this results, the treatment explains 64% of the variability of difference between students Pre-PostASTA scores.

Table 4. 17 Results of paired samples t- Test

	Mean	Std. Deviation	df	t	p
PreASTA	59.703	9,89	80	11.83	.000
PostASTA	71.925	12,23			

4.5 Results of Pre-Post GCT and Student Interviews

The PreGCT included 20 multiple choice items consisting of one correct answer and four distracters. Beside this, PostGCT was a two-tiered questionnaire and consisted of 20 two-tier questions. The first tier includes a multiple choice question the second tier includes the reason of choosing that choice in the first tier in multiple-choice format.

PreGCT was applied before the implementation and after the implementation PostGCT was carried out to students. Table 4.18 shows the percentages of the students who gave correct responses on Pre- PostGCT questions.

Table 4. 18 The percentages of student correct responses on PreGCT and Post GCT

Item No	PreGCT %		PostGCT%			
			First Tier		Second Tier	
	CG	EG	CG	EG	CG	EG
Item1	82	79	69	92	72	100
Item2	74	77	66	88	72	95
Item3	81	82	80	87	82	92
Item4	86	84	85	82	70	85
Item5	68	51	45	76	42	50
Item6	57	60	62	83	47	72
Item7	69	90	76	88	75	92
Item8	32	38	41	77	40	71
Item9	46	54	58	71	60	78
Item10	27	34	91	90	91	92
Item11	86	89	39	59	47	66
Item12	52	52	73	79	77	79
Item13	42	54	68	88	67	87
Item14	34	35	77	78	60	73
Item15	70	62	42	64	53	61
Item16	49	52	61	75	45	80
Item17	46	60	64	75	62	76
Item18	56	55	39	57	41	55
Item19	24	29	81	82	70	75
Item20	51	57	67	65	63	59

In item 1, students were asked that what happen to the molecules of air compressed in a syringe. According to pre-test results proportion of the correct responses were 82% for the control group and 79% for the experimental group. The alternate conception “gases molecules shrink after compressing” was the most common alternative conception seen in the both of groups. The percentage of students having this alternative conception was 14% in the experimental group, while it was only 17% in the control group for PreGCT. Moreover, 7% of the experimental group thought that gas molecules stop moving after compression.

Moreover, proportions of students’ correct responses were under the 30% for the items 8, 10 and 19 for both of the groups. The most significant difference between the scores on the PreGCT for the experimental and control groups was on Item 7 in which 21% of the experimental group students scored greater than the control group students. Item7 was related to the distribution of gas particles in the flask and students were asked the representation of gas particles at 25°C in particulate level. Same question was asked students in a different format in the post test as first question. The percentages of students hold the alternative conception” particles stick to wall of the container” was 11% in the control group and % 6 in the experimental group before the implementation.

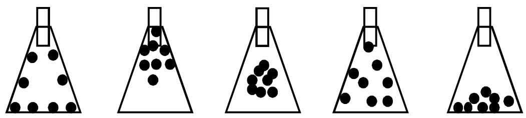
In Item10, students were asked which alternative was wrong about the properties of gases. The percentage of students having the correct response was 34% in the experimental group, while it was only 27% in the control group for PreGCT. 45% of the students in control group and 32% of the experimental group students choose the same alternative conception that is “gas pressure depends on the kind and the number of the atoms that gas includes”.

According to the PostGCT scores, percentages of students’ correct responses in the experimental group were mostly greater than experimental group in terms of all items. Item 3 and Item 10 were correctly responded by experimental and control group students, with the percentages of correct responses above 80 for both of the groups. Another remarkable result is that all of the experimental group students gave correct answer for second tier in Item 1, which refers to the reason of Item 7 in PreGCT. In brief, all of them selected the correct reason that explains the homogeneous distribution of gas particles at all temperatures. However, some control group students keep on hold the alternative conception "particles stick to wall of the container" with the percentage of 9% and they also explained the reason of first tier as "gas particles takes the shape of container" with the percentages of 8%.

In item 2, students were asked represent the distribution of gas particles if the temperature increases from 25 °C to 60 °C as a continuum of item 1. Before the treatment most of the students; 44% for experimental group, 42% for control group; hold an alternative conception and thought that gas particles collected at the top of the container. After treatment, the students' correct response percentage was 88% in the experimental group, while it was 66% in the control group for first tier in PostGCT. In terms of second tier for Item 2, 16% of control group students and 4% experiment group students selected alternative conception that is "Heated gas particles weighs more than cold particles and so gas particles collected at the top of the container". It shows a significant decrease in experiment group students' alternative conceptions. Besides, the 9% percentages of students in control group thought that attraction force between heated particles increase and gas particles accumulated while only % 1 of the experimental group students thought similarly. The alternative conceptions that this item measured and the percentages of experimental and control group students who choose alternative conceptions in the post-test are given below:

According to Table 4.18, the greater difference between the scores for the experimental and the control group were in Items 6, 8, 13 and 16 on the PostGCT.

Table 4. 19 The percentages of students' responses for question 2 in PostGCT

Question 2.1 Consider a 3.00-L flask containing 1.0 mole of N_2 is in a room with a temperature of 25.0°C. If we increase the temperature from 25°C to 60 °C, Which picture below best represents the distribution of gas particles in the flask at 60 °C?  I. II. III. IV. V.	**Percentages of students' responses (%)**	
	CG	**EG**
I. I	10	1
II. II	20	11
III. III	66	88
IV. IV*	1	0
V. V	3	0
2.2.Because; a. The attraction force between heated particles increase and gas particles accumulated.	9	1
b. Heated gas particles weighs more than cold particles and so gas particles collected at the top of the container.	16	4
c. Gas particles distribute homogeneously at all temperature.*	72	95
d. When heated, mass of molecules increase and so gas particles collected at the bottom of the container.	1	0
e. The gas molecules shrink and cluster.	2	0

*Correct Response

In Item 6 students were asked how properties of a matter which move to gas phase from liquid phase changes in a closed container. After the implementation, the percentage of students answered this item correctly was 83% in the experimental group and 62% in the control group for first tier. 31% of the control group students' and 11% of the experimental group students' thought that when a substance goes from liquid to gas state the size of the particles increase. While 17% of control group students thought that the mass of matter changes when it goes from liquid to gas state in a closed container, the 9% percentage of experimental group students thought similar way. In the second tier, 72% of the experimental group and only 47% control group was correctly answered the reason of the content in Item 6. Most of the students in control group thought that molecules expand when the matter goes from liquid to gas and so distance between molecules increases with the percentage of 28% (Option B). It was a most common alternative conception among the students since 11% of the experimental group students thought similar way. Moreover, the percentage of students having another alternative conceptions that is" Gases are lighter than liquids so the mass of the substance decreases." response was 8% in the experimental group, while it was 18% in the control group for in PostGCT. Table 4.20 shows the percentages of students'' responses for sixth question.

Table 4. 20 The percentages of students' responses for question 6 in PostGCT

Question 6.1 Which properties of a substance do change when it goes from liquid to gas state in a closed container?	**Percentages of students' responses (%)**	
	CG	**EG**
I. Size of particles	31	11
II. Distance between gas particles*	62	83
III. Mass	17	6
6.2. Because a. Size of the particles change because of the more collision during the change from liquid to gas state.	4	7
b. Distance between gas particles increase due to increase in the size of the particles.	28	11
c. Gas particles take the shape of container.	3	2
d. During phase change energy stay constant. Distance between gas particles increases due to taken energy.*	47	72
e. Gases are lighter than liquids so the mass of the substance decreases.	18	8

In Item8, students were given a figure which shows the distribution of particles of Hydrogen gas in the flask at 20°C and 3 atm pressures. And then asked, if the temperature decreases from 25°C to -5 °C, what happens to gas particles. The proportion of students having the correct response was 71% in the experimental group, while it was 40% in the control group for both of tiers in PostGCT. The students who gave wrong answer in Item8 showed a common misconception similar with Item6, and they thought that gas particles shrink when the matter is cooled.

In Item 13, students were asked to compare the pressure of three different occasions. For the first tier when 88% of the students in the experimental group and 68% in the control group correctly gave answer, in the second tier; 20% of the experimental group students scored higher than the control group students. Item16 was related to the diffusion of gases. The percentage of students choosing the correct response was 75% in the experimental group, while it was 61% in the control group for first tier. In terms of second tier for Item16, there was a decrease for control group since; only 45% of control group students gave correct explanation.

Moreover, items 9 and 11 had also significant difference between the scores for the experimental and the control group. Both of the items were about ideal gas law. In Item9; while, %13 of the experimental group students scored higher for the first tier, the difference of percentages became 18% in the second tier. Item11 was also scored higher by experimental group students with the percentage of 19 for both of two tiers.

In addition; the most interesting item in PostGCT was the Item4 which is about effect of altitude changes on air pressure. Since, even 85% of the control group students gave correct answer for the first tier which is higher than control group students (82%), the two tier responses showed that the percentage of control group students choosing the correct response was only 70%, so the control group did not choose correct reasons for the question since the percentage of correct responses decreased.

4.5.1 Student Interviews

In the current study, interviews were conducted with eight students from both experimental and control groups based on their knowledge level as low, medium and high. Students' knowledge level was determined with respect to their academic achievements in chemistry lesson. The students were chosen in terms of their PreGCT test results to be interviewed to obtain detailed information about their understanding of gases concepts.

Table 4. 21 The percentages of the students' responses to interview questions

	Experimental Group					Control Group				
	N	A	I	PC	C	N	A	I	PC	C
Distribution of Gas particles at 0 °C	0 0%	0 0%	0 0%	1 25%	3 75%	0 0%	1 25%	3 75%	0 0%	0 0%
Distribution of Gas particles at 25 °C	0 0%	0 0%	0 0%	0 0%	4 100%	0 0%	2 50%	0 0%	1 25%	1 25%
Distribution of Gas particles at 90 °C	0 0%	0 0%	0 0%	0 0%	4 100%	0 0%	0 0%	0 0%	3 75%	1 25%
Diffusion of Gases	0 0%	0 0%	0 0%	0 0%	4 100%	0 0%	0 0%	0 0%	1 25%	3 75%
Relationship among air pressure and altitude	0 0%	0 0%	0 0%	1 25%	3 75%	0 0%	1 25%	0 0%	2 50%	1 25%
Direction of air pressure	0 0%	0 0%	0 0%	0 0%	4 100%	0 0%	1 25%	0 0%	0 0%	3 75%
Definition of Ideal Gas	0 0%	0 0%	0 0%	0 0%	4 100%	0 0%	0 0%	0 0%	0 0%	4 100%
Definition of Real Gas	0 0%	0 0%	0 0%	1 25%	3 75%	0 0%	0 0%	0 0%	3 75%	1 25%
Using Ideal Gas Equation	0 0%	0 0%	0 0%	3 75%	1 25%	0 0%	0 0%	2 50%	2 50%	0 0%

The students determined in the experimental group were labeled as E1, E2, E3, and E4 and the students determined in the control group were labeled as C1, C2, C3, and C4.

The interviews helped to make clear students' misconceptions monitored in gases concept test. The responses of students for the interview questions were categorized as "no response (N)", "alternative conceptions (A)", "incorrect (I)", "partially correct (PC)", and "correct(C)". The distributions of the number and percentages of the students' answers in both groups were given in Table 4.21, and sample sentences were given in the following section. Interview results showed that students in ADI groups had more conceptual understanding of chemistry concepts and held less misconceptions compared to those in TCI groups.

The first and second questions in student interviews were about distribution of gas particles in a closed container when the pressure is held constant. Students were given a figure that shows the distribution gas particles at 25 °C. In the first question they were asked to draw distribution of same particles if temperature decreases 0 °C.

Three interviewees in the experimental group correctly represented homogeneous distribution of gas particles. On the other hand, three interviewees in the traditional group represented all particles in a way that collected at the bottom of container at 0 °C and only one of them draw homogeneous distribution of particles in the container. When the reason was asked students, they mentioned the movement of ability of gases particles decreases with temperature decreases. For example, an interviewee, C3, from the control group stated as the following:

> If the temperature is decreased, the gas molecules have less speed, and so they will move less and particles will slow down. So, gas molecules collect at the bottom when the matter is cooled.

In addition, it was detected that one of the students from control group, C1; held the misconception;" If the temperature decreases the gas particles shrink and collected in the middle of the container. "

As a continuation of first question, in the second question, students were asked what happened same particles if temperature increases 90 °C. All students from experimental group made correct drawing with the appropriate explanation in the third question. One of the students in the experimental group, E4, expressed as the following for gases:

> I think gases homogeneously distribute everywhere, and cover whole space in the container. Similar with air. For example in this class, air is everywhere both summer and winter.

However, control group students had difficulties when representing distribution of gas particles at 90 °C. Although one of the interviewees from control group mentioned about homogeneous distribution of gases, three of them did not mention about it. For instance, one of the interviewees, C2, from the control group stated as the following:

> R: If we increase the temperature from 25°C to 90 °C, you think, what happens to gas particles?
> I: Molecules rise and move to the top of the container because of temperature.
> R: How can you explain rising of gas molecules?
> I: Their weight decreases I think and they can rapidly move to the top.
> R: You mean cold particles weights more than hot ones?
> I: I am not sure but, we know "Hot air rises" in our daily life. So if we increase temperature, particles rise.

The other interviewees from control group stated the similar responses for the third question. It was detected that the students have difficulties since the abstract nature of concept.

The question 3 was related to defining diffusion of gases. All of the students from experimental group and three students from control group could define diffusion of gases correctly. Then, students were asked to give example for diffusion of gases from their daily life. During the interviews, all interviewees gave the same examples for diffusion of gases which were spreading of cologne or perfume odor in a room. Two of the students from experimental group mentioned about HCl and NH_3 diffusion experiment and another student from control group added cigarette smoke diffuses into the air.

The interviewees from experimental group were more confident in explaining concept and giving examples for diffusion of gases and most of them remembered and mentioned the experiment about diffusion they conducted in the laboratory. However, the control group interviewees were less confident in explaining concept and also two of them could give only one example for diffusion of gases.

The following excerpt belongs to a student, E2, from the experimental group:

> R: What is the meaning of diffusion of gases?
> I: All gases can mix into one another
> R: How could it be?
> I: Because of gas particles random movements.
> R: OK. You said all gases mix into other gases. Is it a homogeneous or heterogeneous mixture you think?
> I: I think, if two gases mix, they form homogenous mixtures. Gas particles always move random and so mix homogeneously.
> R: Well, Can you give examples for diffusion of gases in your daily life?
> I: Hmm... If we spray a perfume from here, someone from the other corner of the room smells the perfume odor.
> R: Is it shows gas particles diffuse into one another
> I: Yes. For example, we made an experiment in laboratory. We mixed HCl and NH3 gases in a tube and when they mixed we realized a white smoke. They diffuse into each other.

In the fourth question students were shown four different situations such as a flying bird or a blowing leaf and asked existence of air pressure in these situations. All of the students from experimental group and three students from control group could answer existence of air pressure in all situations. However, one of the students from control group explained as the following: “There is air pressure only if there is wind.

Since wind removes air and air transfer cause air pressure on the things." When the student was asked existence of air pressure when a cat is only standing in a road, the student C1 just said "I think there is no pressure in that situation. Since the students did not observe air pressure directly, they believe that there is no air pressure. Moreover, since they see the effect of wind on things such as blowing leaf, they believe that wind cause air pressure. In other words, abstraction of the concepts might cause this kind of alternative conceptions.

The fifth question probed for students' ideas on atmospheric pressure and what students thought about the atmospheric pressure in different altitudes. First, students were asked to explain the direction of the atmospheric pressure. All interviewees answered correctly by explaining that atmospheric pressure acts from all directions. Only one of the students in the control group had common misconception and stated: "Atmospheric pressure acts downward." When the reason was asked, the student C1 said "I know gravity. It pulls you down; it also pulls the pressure down." The student did not understand the concept pressure and kinetic theory of gases. Then, students were asked whether air pressure is greater at sea level or on top of a mountain. Three students from experimental group and one another from control group explained the difference using relation between amount of the air and altitude. One of them, E2, explained as following:

> Air pressure increases when you climb high and decreases when you come down. There was much air at the sea level and less air on the top of the mountain. If you climb high, the less air affects you. I mean the pressure affects you will be less because of amount of air.

Similar to E2's opinion another interviewee C3 said at sea level there is more air above us than top of the mountains. Another interviewee, E1, stated air pressure decreases when you climb high but could not explain why it could happen just said he remembered that air pressure was less in a plane than here. The other interviewees had difficulties when answering this question, since, instead of explaining conceptually, they just tried to remember what they memorized before. Although the other two students gave the correct answers, they were insufficient in terms of explaining the phenomenon behind the concept of air pressure.

In question 6, students were asked to explain the ideal gas. All interviewees mentioned about high temperature and the low pressure. Two of the students told that ideal gas was an assumption and there was no such gas on the world. The latter students were also asked whether they heard about real gas and two of them told that they knew about the conditions in which a real gas behaves like ideal gas, but one of them said ideal gas was an assumption to make easy calculations. One of the students who supported this idea was E3, his explanation is given below:

> Ideal gas and real gas… İdeal gas has more space between molecules and interactions between molecules are zero. Besides, they have negligible molecule volume. But, there was no ideal gas we learned before in the lesson. But I know, If we increase temperature and decrease pressure, real gases behave like ideal gases. But as I said there was no ideal gas in the world. We only assume to use ideal gas formula.

While all of the students from experimental group talked about interaction between gas molecules, none of the students from control group could mention about the attraction between gas particles.

An excerpt from the interview with the interviewee, C4, is as follows:

> R: What is an ideal gas?
>
> S: İdeal gas… High temperature and low pressure… gases became ideal.
>
> R: What are the properties of an ideal gas?
>
> S: Only high temperature and low pressure comes to my mind.
>
> R: OK. What happens to gas particles you think at high temperature and low pressure?
>
> S: Hmm... If temperature increases, gas particles would move faster and they collide each other.
>
> R: What about the interaction between gas molecules? Think about space between gas particles.
>
> S: Yes. There was more space between them but I know they have interactions. I think I confused something…

As seen from excerpt, when the question was asked under the which conditions gases behave ideally, he could mention about the conditions in which a gas behave ideal but not explain how the gas is affected temperature increase or pressure decrease. Since he just made memorization, he was confused.

In the last question students were given a problem that there are 3 moles of gas at 273 K in a container with movable piston. When the students were asked if 1 mole extra gas added and temperature increased, which properties of the gas change or not change, students gave various responses. Two students from experimental group and two students from control group stated that pressure would stay constant and volume of the gas would increase. The other interviewee, E1, from the experimental group explained that since this was not a closed container, if the amount of gas increase, the volume of gas would increase and so pressure would not change. Two of the students from control group could not notice how pressure of the gas is impressed in a container with movable piston. Both of them could not make any reasonable explanation for the situation. One of the students from experimental group, E2, thought in terms of particulate level and stated as the following;

> If the temperature increases, kinetic energy of the molecules increases… because the distance between the molecules increases the molecules move faster. So the volume increases.

Two of the interviewees from control group stated that both pressure and volume of the gas would increase. Though they were warned about the movable piston in system, the students could not give appropriate explanation for the situation. Since ideal gas laws were known by most of the students, some of them could not construct the correct relationship among the variables in the ideal gas equation.

4.6 Results of the Classroom Observation Checklist

In order to evaluate the classroom observation checklists, first scores of observers were entered the SPSS program and then means of all items were calculated. After conducting descriptive statistics, correlations between the two observers were found for each group.

There were 19 items in the checklist and the items related to the control group are Items 3 and 17 that indicate the basic characteristics of traditional instruction followed in this study. The items related to the common group are Items 1, 2, 7, 11, 15, 16, 18 and 19. These items are common for all treatments. The other items were only appropriate for the treatment of experimental group and coded as NA in the traditional group. The experimental groups and control groups were observed five times by one observer and 3 times by both of two observers.

Table 4. 22 Results of classroom observation checklist

Item No	Experimental Group		Control Group	
	Mean	S.D.	Mean	S.D.
1	2.4	0.3	2.3	0.5
2	2.3	0.5	2.6	0.5
3	**3**	0.0	1	0.0
4	1.0	0.0	**3.0**	0.0
5	1.0	0.0	**2.6**	0.5
6	1.0	0.0	**3.0**	0.0
7	1.9	0.5	2.3	0.5
8	1.0	0.0	**2.6**	0.5
9	1.0	0.0	**3.0**	0.0
10	1.0	0.0	**2.8**	0.0
11	3.0	0.0	2.5	0.7
12	1.0	0.0	**2.5**	0.5
13	1.0	0.0	**2.3**	0.5
14	1.0	0.0	**3.0**	0.0
15	1.6	0.8	2	0.0
16	1.6	0.5	3.0	0.0
17	**2.8**	0.0	1	0.5
18	2.0	0.3	2.4	0.5
19	1.3	0.5	2.8	0.5

Table 4.22 shows descriptive statistics of each item in the checklist. The items belong to each group are represented with bold characters to analyze the data in the table more easily. It is clear that the means of items related with the control group were higher than those of the experimental group. The items 4, 5, 6, 8, 9, 10, 11, 12, 13 and 14 were related to ADI instructional model. It was estimated that experimental group had higher means related these items than control group. As seen from the table 4.22 the mean scores of those items for experimental group were higher than mean scores in the control group.

Table 4. 23 Correlations between two observers

Lectures	1 CG	2 CG	3 CG	1 EG	2 EG	3 EG
r	0.84	0.72	0.82	0.86	0.81	0.89

In order to obtain reliable results from the observation checklist, three lectures from control group and three lectures from experimental group were observed by two observers. Table 4.23 shows the correlation coefficients between these two observers. As seen from Table 4.23, the correlations between observers are high.

4.7 Summary of the Results

The summary of the results could be listed as following;

- The ADI instructional model resulted with significantly higher conceptual understanding scores on the gases concepts when compared to the traditional instruction.
- The students who received ADI instructional model developed better attitudes towards chemistry when compared to the students those received traditional instruction.
- The ADI instructional model caused a significant decrease in experiment group students' alternative conceptions more than control group students.
- There was no significant interaction effect between treatment and gender on students' conceptual understanding scores on the gases concepts and their attitudes towards chemistry.
- Although the interaction effects are not significant, male students seem to benefit more from ADI instructional model in terms of their attitudes towards chemistry and their conceptual understanding on the gases concepts.
- Students who taught by Argument-Driven Inquiry instructional model showed a significant increase in terms of willingness to pursue of argumentation.

CHAPTER 5

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

This chapter covers five sections; these sections begin with a discussion of the results. The internal and external validity are presented next. Finally, implication of the results and recommendations for further research are followed.

5.1 Discussion of Results

The main purpose of this study was to seek whether there is a significant effect of Argument-Driven Inquiry (ADI) instructional model on 10^{th} grade high school students' conceptual understanding and attitudes toward chemistry as compared to traditional chemistry instruction (TCI) and to draw conclusion based on the evidence for students' conceptual understandings of gases concepts and attitude toward chemistry between the experimental and traditional groups. To be clear the focus of study was to generate scientific argumentation in order to improve development of conceptual understanding of students in chemistry and enable students to develop more positive attitudes towards chemistry by using ADI instructional model. The ADI instructional model provides a firsthand experience by inquiry process embedded in argumentation for students who never have such an opportunity. Thus, students might develop their own methods in a scientific investigation that facilitate meaningful learning when compared to traditional instruction. The experimental group students were implemented into the chemistry laboratory by ADI instructional model based activities during the implementation process. Besides, control group students were also implemented into the laboratory in order to make the treatment less novel and they followed step-by-step procedure for investigations and solved more algorithmic questions. The lectures in control group were predominantly teacher oriented.

As aforementioned, there are number of researchers interested in strategies to integrate argumentation into the teaching and learning of science with inquiry (Bybee et al., 2004; Carin et al., 2005; Cavagnetto, 2010; Clark & Sampson, 2007; Eisenkraft, 2003; Erduran, et al., 2004; Kingir et al.,2012; Marek & Cavallo, 1997; Sampson & Gleim, 2009; Sampson et al., 2009; Simon et al., 2006; Simonneaux, 2001; Walker & Zeidler, 2007). However, there are few studies about argumentation-based inquiry particularly in Turkey (Akkuş et al., 2007; Demirbağ & Günel, 2014; Günel et al., 2010; Kıngır, 2011; Kıngır et al., 2012). Moreover, there is not found any study that aimed to design ADI instructional method in chemistry instruction in Turkey. This study might be considered as one of the first attempt to design and implement ADI instructional model in Turkish chemistry context for high school students and evaluate the effectiveness of method with pre-posttest design. This current study is also important in terms of introducing the ADI instructional model to Turkish chemistry education.

Before the instruction, pretests assessing students' conceptual understanding of chemistry concepts and attitudes toward chemistry were aapplied to the students in both groups in order to control pre-existing differences between groups. In other words, those tests were also aimed to have opinion of equality of groups at the begging of the study. The analyses of pre-tests indicated that mean scores on PreGCT and PreASTC were equaled for experimental and control groups. The mean scores on PreGCT and PreASTC were 11.72 and 45.04 in the control group, and 11,56 and 45,45 in the experimental group. Based on the minimum and maximum values that can be obtained from PreGCT (min = 0, max = 20) and PreASTC (min = 0, max = 75), the mean scores of PreGCT that shows the level of students' previous knowledge in gas concepts was approximately medium level before the instruction. Since students are given formal instruction about some gases concepts from the beginning of sixth grade to end of the middle school. So, the main reason under these medium level scores was students had some pre-existing knowledge about gases concepts before the implementation.

According to result of t-test for equality of groups there were no significant mean differences between experimental and control group students in terms of their understanding of gases concepts before the treatment. In other words, students in both groups could be assumed to be equal in terms of their prior knowledge. Prior knowledge is important to make connections with new incoming knowledge and existing knowledge. According to Ausubel (1968), learning occurs when new information is linked to what have already known. Therefore, prior knowledge is the most significant factor to determine what new learning will occur. Similarly, Bruner (1961) suggested that knowing something about learner's prior knowledge is essential in order to decide which representation is appropriate for learner when organizing instruction (as cited in Driscoll, 2005). Hence, it is crucial to know what existing knowledge students come with class to help them construct new knowledge (Tsai, 2000a, 2000b). Von Aufschnaiter et al.(2008) reported that prior knowledge has an important role for generating good argument and students employ these knowledge and experiences at relatively high levels of abstraction. Since there was no difference between the students in the experimental and control groups with respect to their prior knowledge of gases concepts, there was no need to use pre-tests scores as a covariate to control pre- existing differences in this study. More clearly, since the groups are equal in terms of prior knowledge, the differences of students' prior knowledge would not affect or confound the results of study with regard to effectiveness of instructional methods.

Pre-tests analyses also showed that mean scores on PreASTC were equal for experimental (45.45) and control groups (45.04), in terms of difference between the students' attitudes toward chemistry in both groups. As a second step, to be sure correlations among all variables were computed. The results of correlations among variables indicated that PreASTC have significant correlation with at least one of the dependent variables. Hence, the correlation between pre and posttests of attitude toward chemistry might affect the effectiveness of ADI instructional model, this independent variable (PreASTC) was decided to be used as a covariate for inferential statistics of the study.

After the over seven weeks treatment for both of the groups, posttests on students' conceptual understanding on gases concepts (GCT-II) and students' attitudes toward chemistry (ASTC) were applied at the seventh week both of the groups. First, the descriptive statistics was conducted for each variable and then for the inferential statistics, multivariate analysis of covariance (MANCOVA) was conducted with two dependent variables, which were PostGCT and PostASTC; two independent variables, which were teaching method and gender; and one covariate, which was PreASTC. Before conducting MANCOVA, all variables were checked for assumptions of MANCOVA.

Additionally, a paired-samples test was conducted to investigate the effect of ADI instructional model on students' scores on the ASTA in terms of a person's tendency to pursue or avoid of argumentation in argumentative situations as pre-posttests. The scale was applied only experimental group students before and after the treatment because the implementation of argumentation. It was found that there was a statistically significant increase in students' tendency of argumentation from PreASTA (59.703) to PostASTA (71.925) scores. In other words, students who engaged ADI instructional model activities during treatment had higher scores at the end of the instruction in terms of tendency of argumentation when compared at the beginning of the instruction. This result is parallel with the Kaya's study (2005) that reports a significant increase of experimental group students' willingness to pursue of argumentation. Moreover, Kaya (2005) documented that there was a significant correlation between students' achievement and their tendency to pursuit of argumentation.

The result of the study indicates that the experimental group students on the PostGCT had statistically significantly higher scores than control group students in terms of understanding gas concepts. Thus, all reported findings of this study come together, it can be concluded that the ADI instructional model resulted in a significantly better acquisition of the understanding of gas concepts when compared with the traditional instruction. Although the PostGCT was a two-tiered diagnostic test students in both groups increase correct answers, but the experimental group students indicated more significant growth than the control group students. According to the PostGCT scores, percentages of students' correct responses in the experimental group were mostly greater than experimental group in terms of all items. Thus, based on the inferential statistic results, it can be concluded that students' conceptual understanding of gas concepts was improved with the ADI instructional model. The most significant difference between the scores on the PostGCT for the experimental and control groups was on Item8 in which 71% of the students gave correct answer in the experimental group, while it was 40% in the control group. The question was about the general representation of distribution of Hydrogen gas particles in the flask at 20°C and 3 atm pressures at particulate level. And then students were asked if the temperature decreases from 25°C to -5 °C, what happens to gas particles. The students who gave wrong answer in Item8 showed a common alternative conception and thought that gas particles shrink when the matter is cooled. Similar results were found to be for the representation of distribution of gas particles at 60 °C in item2 in favor of the experimental group students. As a result, it can be concluded that the ADI instructional model was more influent in understanding of representation of substances at microscopic level when compared the traditional chemistry instruction. These results are similar with studies in the literature that investigate the effect of ADI instructional model on students' conceptual understanding in science context (Sampson et al., 2010; Sampson et al., 2013; Walker et al., 2013; Enderle et al., 2013). Moreover, a number of studies focusing on the effects of argumentation based instruction using pre/posttest design support this evidence and documented that students who were instructed argumentation-based instruction developed better conceptual understanding than those in the control group (Aydeniz et al., 2012; Jime´nez-Aleixandre et al., 2000; Jime´nez-Aleixandre & PereiroMunhoz, 2002; Kaya, 2013; Kıngır, 2011; Mason, 1996; Venville & Davson, 2010; Zohar & Nemet, 2002). In order to increase conceptual understanding in scientific concepts and enhance the construction of meaningful learning for students, it is effective for students to engage in argumentation based instruction. Therefore, this current study is consisted with the studies in the literature.

During the implementation in experimental group, students learn to propound a scientific method to be followed during an investigation in order to answer a research question though the process of learning scientific concepts with inquiry, argumentation, and writing in science and engage in peer review (Sampson, Grooms, & Walker, 2010; Sampson & Gleim, 2009). Hence, ADI instructional model might improve students' understanding of the gas concepts by providing a firsthand science experiences (Driver et al., 1994; Duschl, 2000) with inquiry based activities. The activities used in this study, in particular; laboratory investigations probably contributed to students' success in experimental group. In all activities, students are given an opportunity to conduct an investigation method that designed by them in order to produce data or to test the questions. Moreover, chemical concepts were taught as a part of laboratory activities. Students' activity sheets include chemical concepts related to the topic and a researchable question which is needed to answer. Since the procedure being followed by students are uncertain in activities, students were provided an opportunity to understand the way scientist follow by doing science through designing method, interpret empirical data and evaluate new explanations. Thus, students followed their own methods in a scientific investigation as a meaningful way for themselves on the contrary of step-by-step procedure in their traditional laboratory.

After the implementation, it was found that there were differences in the proportions of correct responses of students in experimental and control group, in favor of the experimental group and the some common alternative conceptions held by experimental group students were fewer than control group students. For example, 31% of the control group students' and 11% of the experimental group students' thought that when a substance goes from liquid to gas state the size of the particles increase. In another question, most of the students in control group thought that molecules expand when the matter goes from liquid to gas and so distance between molecules increases with the percentage of 28%. It was a most common alternative conception among the students since 11% of the experimental group students thought similar way. Moreover, the percentage of students having another alternative conceptions that is "Gases are lighter than liquids so the mass of the substance decreases." response was 8% in the experimental group, while it was 18% in the control group for in PostGCT. These results are consisted with the ideas that emphasize the conceptual change is not an easy process and still there were contradictions, resistances, and progressive conceptual change with considerable and consistent improvement in the some items (Niaz et al., 2002).

Most specifically, in Item 2, before the treatment most of the students; 44% for experimental group, 42% for control group; hold an alternative conception and thought that gas particles collected at the top of the container. After treatment, students who have the correct response have the percentage of 88% in the experimental group, while it was 66% in the control group for first tier in PostGCT. In terms of second tier for Item 2, 16% of control group students and 4% experiment group students selected alternative conception that is "Heated gas particles weighs more than cold particles and so gas particles collected at the top of the container". It shows a significant decrease in experiment group students' alternative conceptions. A similar improvement was also observed for the common items in both of concept test which are Item6, Item8, Item9, Item11, and Item13 for experimental group students. Therefore it can be concluded that conceptual change might have occurred by generating arguments since the high conceptual engagement in ADI implementation for experimental groups. Students in such an argumentation process based on inquiry (ADI), constructed their own explanation and created rebuttals against the explanations that they did not agree with. Embedding argumentation in science learning helps to make scientific reasoning visible (Duschl &Osborne, 2002). It is possible that the opportunity to reflect on students' experimentation and explanation such an implementation that generally not provided in traditional instruction may have elicited students' alternative conceptions. Consequently it can be concluded that ADI instructional model provides students to gain a deeper conceptual understanding in gases concepts and minimize or eliminate alternative conceptions that students hold. The findings of the studies focusing on the effects of argument based instruction also support this result (Aydeniz et al., 2012; Kıngır, 2011).

Besides the students' improvement of conceptual understanding of gas concepts, there are also increase students' attitudes towards chemistry. When the PostASTC scores of students examined, the experimental group students had significantly higher scores than control group students with regard to attitude toward chemistry. This result implied that experimental group students seem to develop more positive attitudes toward chemistry than control group students. During the implementation of ADI, laboratory activities provide students a firsthand experience doing science.

Though the process of learning scientific concepts with ADI, students learn to propound a scientific method to be followed during an investigation in order to answer a research question. On the other hand, uncertain nature of activities used in ADI aroused students' curiosity. In other words, students felt involved in chemistry like a scientists. Thus, experimental group students' attitudes toward science improved positively. The results consistent with the Walker et al.,(2012)'s study that examines the effect of ADI instructional model on students' attitudes toward science. Students' attitudes are also associated with their achievement and the development of positive attitudes toward chemistry could motivate students to learn chemistry (Osborne et al., 2003). In this study, since the students who have more positive attitudes had more willingness to involve in ADI activities.

Many studies reported different results in terms of attitudes and gender in the literature. In these studies, some of them concluded that boys have a more positive attitude toward science than girls (Koballa & Gylnn, 2007; Simpson & Oliver, 1985; Rani, 2000; Reiss, 2004; Weinburgh, 1995). However, many of other studies stated that girls have more positive attitudes than boys (Akpınar et al., 2009; Dhindsa & Chung, 2003; Walker et. al., 2012). When students science achievement is taken into account, some studies reported that boys had better performance in science than girls (Weinburgh, 1995), and some studies documented that the gender differences are in favor of girls (Britner, 2008; Britner & Pajares, 2006). The results of current study revealed that students' conceptual understanding of gas concepts and attitudes toward chemistry did not differ in terms of gender. In other words, ADI instructional model of instruction did not lead to bias on gender. Moreover, treatment had equal effect on males and females regardless conceptual understanding of gas concepts and attitude toward chemistry.

The interviews helped to examine students' alternative conceptions and it was found that the alternative conceptions detected by PostGCT were consistent with results of interviews. Most of the detected alternative conceptions during interviews were similar with the studies in the literature (e.g. Aslan & Demircioğlu, 2014; Hwang, 1995; Hwang & Chiu , 2004; Mas et al., 1987; Mayer, 2011; Niaz, 2000; Novick & Nussbaum, 1978; Stavy, 1990) Many of the students in control group and some students in the experimental group could not support their explanation scientifically with appropriate reasons in the representation of particulate level. For example, students were given a figure that shows the distribution gas particles at 25 °C and they were asked to draw distribution of same particles if temperature decreases 0 °C. Three interviewees in the experimental group(75%) correctly represented homogeneous distribution of gas particle while three interviewees in the traditional group represented all particles in a way that collected at the bottom of container at 0 °C and only one of them draw homogeneous distribution of particles in the container(25%). In addition, it was detected that one of the students from control group held the alternative conception;" If the temperature decreases the gas particles shrink and collected in the middle of the container. " As a continuation of first and second questions, in the next question, students were asked what happened same particles if temperature increases 90 °C. All students from experimental group (100%) made correct drawing with the appropriate explanation while only one of the interviewees (25%) from control group mentioned about homogeneous distribution of gases, three of them did not mention about it. These results are consistent with the conclusion of Nakhleh (1994) who concluded that students had difficulties in understanding of the particulate level of matter. In addition, it was found that the students have difficulties in understanding the concepts which had abstract nature and microscopic level of matter such as gas concepts. Briefly, it was detected that the control group students have more difficulties since the abstract nature of concept and "particulate nature of matter" did not much taken into consideration during the treatment process. Since the control group students hold more alternative conceptions when compared experimental groups at the end of the study, an improvement was also observed for the control group students' conceptual change. There may be two possible reasons for the improvement performance of the control group students. First, making experiments was a novel experience for control group students and it could increase their curiosity, interest and hence causes interpret empirical data by reasoning. Then, experimental and control group students could make an out of class discussion.

Consequently, results obtained in this study show that given the opportunity to argue and discuss based on inquiry, students' conceptual understanding could go beyond the simple memorization of conceptions during experimentation. In addition, providing students science laboratory experiences that are more authentic and educative for with inquiry and argumentation might have been developed students' conceptual understanding of gas concepts in the experimental group. Thus, as the qualitative results illustrate, the ADI instructional model of instruction was effective with regard to improve conceptual understanding of gas concepts than the traditional instruction.

5.2 Internal validity

Internal validity refers to "observed differences on the dependent variable are directly related to the independent variable and not due to some other unintended variable" (Fraenkel & Wallen, 2003, p.178). There are some possible threats to internal validity of a study. These are: subject characteristics, mortality, location, testing, history, and instrumentation, and maturation, attitude of subjects, regression, and implementation. In this section, the current study is analyzed with regards to these possible treats to internal validity.

Subject characteristics: In this study, since the subject characteristics difference between the groups could affect or explain the results of the study. The groups were formed by random assignment. Moreover, many of the subject characteristics such as gender, age, prior knowledge of gases concepts and attitudes toward chemistry could affect the results of study. In order to eliminate or minimize the effects of subject characteristics, students' age, gender and prior knowledge of gases concepts were investigated and found similar to each other in this current study. Further, in order to equate groups, variables were assigned as covariates (PreASTC) using MANCOVA.

Mortality: Mortality threat refers the loss of subjects in a study. Because of some reasons such as illness etc. some subject may not attend the study or some subjects may be absent when collecting data. In this current study, students who were missing in at least two dependent variables were excluded from the data set. Thus, 6 students were excluded list wise. In addition, rates of missing data are generally considered 1-

5% manageable (Acuna & Rodrigez, 2000).Since the missing values do not exceed 5% of the whole data, they were replaced with the mean values and new data sheet was used during the statistical analyses in this current study.

Location: Location threat may affect the outcome of the study if there are different conditions such as different classes, supplies etc. for groups. In this study, experimental group students were implemented into the chemistry laboratory. Beside this, make the treatment less novel for control groups, the teachers also conducted chemistry lessons into the laboratory in the most of the weeks. In order to control this treat, researcher obtained more information to eliminate the location threat for the groups.

Instrumentation: This threat can be examined under three dimensions, which are instrument decay, data collector characteristics, and data collector bias. Instrument decay refers changing in instrument or scoring method. In this study, same instruments were administered both of the groups. In other words, instruments were same in terms of administration and scoring Thus, instrument decay was removed by data collection and scoring. The characteristics of the data collectors such as language, gender or age can also influence results of the study. This threat was controlled by conducting treatment with same teacher for the experimental and control groups and collecting data with same data collector. Lastly, data collector bias was eliminated by training teacher to provide a standard process while collecting data.

Testing: If the students take the same test more than once, they could perform same and their answers could cause errors of measurement (Fraenkel & Wallen, 2006). Therefore, students should be given sufficient time for the desensitization. In this study, three different pre-tests were administered to the students. As a post test of concept test different but equivalent form of PreGCT was used at the end of the study. On the other hand, since the time interval between two administrations is appropriate -6 weeks- for other pre-tests, pre-test effect on the post-test was controlled.

History: During the implementation, unplanned external events can affect the results of the study. The tests were applied to all groups approximately at the same time and, any unplanned events did not occurred during the study. Thus, history threat was controlled in this study.

Maturation: Maturation threat refers the changing the subjects in many ways due to growing old and experience. Since the time of the study only seven weeks this treat was not affect the outcomes of the study.

Attitude of subjects: Subjects knowledge about the study may influence on the results of study. This threat can be examined under three sections, which are Hawthorne effect, John Henry effect, and demoralization. Hawthorne effect is positive effect on experimental group students since experimental group students can improve their knowledge due to novelty of the treatment. John Henry effect is also another effect that control group students may show an extra effort to make better than experimental group students due to novel circumstances of experimental group students. Demoralization effect explains that control group students may become demoralized and perform poorly due to unfairness. In this current study, in order to eliminate and minimize these threats teacher told students the instruction was not different from each other and made similar activities and experiments in laboratory in both groups. On the other hand, there might have been an interaction between the students of experimental group and control group in terms of implementation of instruction. Therefore, attitude of subjects might be a threat for this study.

Regression: This threat could be possible if low or high achievers selected from groups. Therefore results might have been explained due to regression of extreme groups. Since, the random assignment was used to choose the groups in this study; therefore, this threat did not impact the results of the current study.

Implementation: Results of study could have been explained differences between implementers or biases of implementer. In this study, the same teacher implemented in both experimental and traditional groups and the teacher was taught before the implementation. Moreover, implementation was observed during the study and classroom observation checklists were used in order to eliminate or minimize this threat. Thus, treatment verification was enabled.

5.3 External validity

The external validity refers to "applying results of a study that can be generalized from a sample to a population" (Fraenkel & Wallen, 2003). One of the main goals of this study is also generalize the results like most of experimental study. The accessible population of this study was all tenth grade students at public high schools in Yenimahalle, Ankara. There were 18 high schools and five Anatolian high schools in the accessible population, one of them were included in this study.

The results of the study showed that there were significant differences on overall the effect of treatments in terms of ADI instructional model and traditional chemistry instruction on the population mean of the collective dependent variables of tenth grade students' post-test scores of gas concepts and attitude toward chemistry in favor of ADI instructional model. The number of students joined in the study was 157 that exceed the 10% of the accessible population. Hence, the findings of the current study might be generalized to the accessible population of the study.

5.4 Implications

The suggestions of this study are as the following:

- Since there is not encountered any study about the implementation of ADI instructional model in chemistry education in Turkey, findings of the current study can contribute to Turkish chemistry education by presenting the ADI instructional model to chemistry education. The findings also help teachers as a guide , textbook writers and curriculum developers in Turkey and other countries when designing an effective lesson for gas concepts.
- ADI instructional model have a positive effect on students' attitudes towards chemistry So, ADI should be used in order to increase students' attitudes towards chemistry.
- The ADI instructional model has been found more effective than traditional chemistry instruction in terms of students' conceptual understanding on gas

concepts. ADI instructional model should be used in order to improve students' conceptual understanding gas concepts.

- According to concept test results students hold many alternative conceptions about gas concepts. Students' existing knowledge should be taken into consideration before the instruction.
- Many of the students have difficulties in understanding the particulate nature of matter particularly gas concepts in high schools. So, teachers should underline the basic concepts and their relation to each other and also should take students' alternative conceptions into account and design the instruction based on these concepts.
- Laboratory based instruction that includes inquiry and exploration should be designed to promote students' critical thinking skills and reasoning in science.
- Real world experiences that include natural phenomenon should be used in instruction to promote positive student outcomes to learning.
- Two-tier test should be used to evaluate students' conceptual understanding and to determine alternative conceptions.
- Teachers should be informed about ADI instructional method and should be supported about implementation about process.
- Representation of substances at microscopic level should be done effectively for understanding of gas concepts.

5.5 Recommendations for Further Researches

According to the results of the study, the following recommendations can be suggested:

- Similar studies can be conducted with a larger sample size and in different types of high schools for the generalization of the findings to a larger population.
- The ADI instructional model can be implemented for different grade levels.
- The ADI instructional model can be used when teaching different science topics.

- This study covered one chemistry topic in short-term. The ADI approach could be used at different grade levels and different chemistry topics as a long-term study.
- Further research can be conducted to seek the effect of ADI instructional model on retention of the concepts.
- Further research can be carried out in order to examine the effects of ADI instructional model on students' motivation, nature of science knowledge, science process skills, problem solving skills, or epistemological beliefs, besides the conceptual understanding and achievement.
- In further studies, discourse analyses can be conducted for the classroom interaction in ADI learning environment.
- Further studies can use a video-record for ADI class sessions. So, the video records can be used for the treatment verification.

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APPENDIX A

INSTRUCTIONAL OBJECTIVES OF THE GASES SUBJECT

Gazlar Konusundaki Kazanımlar
Gazların genel özellikleri ile ilgili öğrenciler, 1. Gazların sıkışma/genleşme sürecindeki davranışlarını sorgular, gerçek gaz ideal gaz ayırımı yapar. 2. İdeal gazın davranışlarını açıklamada kullanılan temel varsayımları irdeler. 3. Gaz basıncını molekül hareketleri temelinde açıklar. 4. Gazların betimlenmesinde kullanılan özelliklerini ve bunların ölçülme yöntemlerini açıklar. 5. Gaz davranışlarını kinetik teori ile açıklar. 6. Kinetik teorinin temel varsayımları kullanılarak Graham difüzyon ve efüzyon yasası türetilir. *Gaz kanunları ile ilgili öğrenciler,* 1. Belli miktarda gazın sabit sıcaklıkta basınç- hacim ilişkisini irdeler.(Boyle Yasası) 2. Belli miktarda gazın basıncı sabitken sıcaklık – hacim; hacmi sabitken sıcaklık-basınç ilişkisini irdeler(Charles kanunu). 3. Belli sıcaklıkta bir gazın sabit basınç altında mol sayısı-hacim ve sabit hacimde iken mol sayısı-basınç ilişkisini açıklar.(Avogadro kanunu) 4. İdeal gaz denklemini kullanarak bir gazın basıncı kütlesi, mol sayısı, hacmi, yoğunluğu ve sıcaklığı ile ilgili hesaplamaları yapar(ideal gaz). 5. Deneysel yoldan türetilmiş gaz yasaları ile ideal gaz yasası arasında ilişki kurar. 6. Boyle, Charles ve Avogadro yasalarından yola çıkılarak ideal gaz denklemi türetilir. 7. İdeal gaz denklemi kullanılarak örnek hesaplamalar yapılır. 8. Normal şartlarda gaz hacimleri kütle ve mol sayılarıyla ilişkilendirilir. *Gaz karışımları ile ilgili öğrenciler,* 1. Kısmi basınç ve kısmi hacim kavramlarını açıklar. 2. Gaz karışımları ile ilgili hesaplamaları yapar. 3. Gaz karışımlarının kısmi basınçlarını gündelik hayattaki örnekleri üzerinden açıklar. *Gerçek gazlarla ilgili öğrenciler,* 1. İdeal gaz kavramının fiziksel gerçekliğini irdeler 2. Gerçek gazların hangi durumlarda ideallikten saptığı irdelenir.

APPENDIX B

CONCEPT LIST AND LIST OF SUBTOPICS OF THE GASES SUBJECT

Ünitedeki Konular	**Kavram listesi**

• Gazların genel özellikleri
    • Maddenin gaz hali
    • Gazların sıkışma ve genleşme özelliği
    • Gazların kinetik teorisi
    • Gazlarda basınç, hacim, mol sayısı ve sıcaklık ilişkisi
• Gaz yasaları
    • Boyle-Mariotte kanunu
    • Charles kanunu
    • Avogadro kanunu
• İdeal gaz yasası
• Gazlarda kinetik teori
    • Difüzyon/efüzyon
• Gerçek gazlar
    • Buharlaşma/yoğuşma
• Gaz karışımları
    • Kısmı basınç
	• Basınç
	• Hacim
	• Mol
	• Avogadro sayısı
	• Mutlak sıcaklık
	• Kinetik Teori
	• Standart-normal şartlar
	• İdeal gaz
	• Gerçek gaz
	• Difüzyon
	• Efüzyon
	• Kısmı basınç
	• Kısmi hacim

APPENDIX C

TABLE OF SPECIFICATION CHECKLİST FOR EXPERTS
UZMAN DEĞERLENDİRME FORMU

10. sınıf kimya öğretim programındaki "Madenin Halleri" ünitesi kapsamında, "Gazlar" konusundaki öğrenci başarısını ölçmek için bir test hazırlanmıştır. Testin geliştirilmesinde aşağıdaki hususlar dikkate alınmıştır:

1. Mevcut kimya öğretim programındaki kazanımlar ve beceriler mümkün olduğunca iç içe olacak şekilde tek bir soru ile ölçülmeye gayret edilmiştir. Bunun yapılamadığı durumlarda, kazanım ve beceriler bölünerek birden fazla soru oluşturulmuştur.
2. Öğretim programında bazı beceriler farklı kazanımlarda birkaç kez yer almaktadır. Bu durumda, söz konusu becerilerin en az bir soru ile de olsa ölçülmesine çalışılmıştır.
3. Sorular, 10. sınıf öğrencilerinin anlayabileceği dil düzeyinde yazılmaya çalışılmıştır.
4. Bu ünite kapsamında kazanımların bazılarında bulunan "Tutum ve Değerler" (TD) becerileri bu test kapsamı dışındadır.
5. Açıklama-sınırlama, açıklama-uyarı kısımları birer kazanım gibi düşünülmüş ve soruların birçoğuna yedirilmiştir. Testteki 20 soru iki aşamalı olup ilk kısım sorunun cevabını içeren çoktan seçmeli sorulardan oluşmakta ikinci kısımda ise birinci aşamadaki cevabın nedeni içeren yine çok seçmeli ikinci bir kısım içermektedir. Bu Form ile yalnızca öğretim programında 10. sınıf Madenin Halleri" ünitesi kapsamında, "Gazlar" konusunda verilen kazanımların, bu testte sorulan sorularla ölçülüp ölçülmediğinin değerlendirilmesi yapılacaktır. Form 2 hazırlanırken;

1. Öğretim programındaki sırasına göre önce kazanımlar (bilgi + beceri+ açıklama-sınırlama, uyarı) yazılmıştır.
2. Kazanımlarla ilgili sorulan sorular, testteki soru numaraları aynen korunarak forma yazılmıştır.
3. Sorulan soru ile ölçülen kazanımlar gerekli açıklamalarla beraber yazılmış, hemen ardından gelen tablo ile sizlerin değerlendirmesine sunulmuştur. Testteki soru ile ilgili kazanımın ölçüldüğünü düşünüyorsanız ilgili alanı (X) şeklinde işaretlemeniz yeterlidir.
4. Ölçülmediğini düşündüğünüz kazanımlar için her türlü önerilerinizi ise tablonun sağ tarafında verilen "Açıklama" kısmına yazmanız istenmektedir.
5. Önerilerinizi size ayrılan boş satırlar dışında da size kolay gelen her şekilde verebilirsiniz.

Bizlere gerek telefonla gerekse e-posta yoluyla her zaman ulaşabileceğinizi hatırlatır, ilginiz ve emekleriniz için şimdiden çok teşekkür ederiz.

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UZMAN DEĞERLENDİRME FORMU

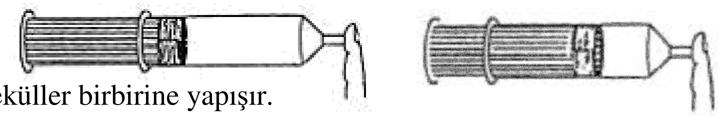
Soru	İlgili Kazanım	Ölçülebilir	Ölçülemez	Açıklama
1.	Gazların genel özelliklerini kavrayabilme			
2	Gazların genel özelliklerini kavrayabilme			
3	Belli miktarda gazın sabit sıcaklıkta basınç- hacim ilişkisini irdeler.			
4	Belli miktarda gazın sabit sıcaklıkta basınç- hacim ilişkisini irdeler.			
5	Gazların sıkışma/genleşme sürecindeki davranışlarını sorgular,			
6	Katı, Sıvı ve gaz fazları moleküller özellikleri temelinde karşılaştırır.			
7	Sıvı ve gaz fazları moleküller özellikleri temelinde karşılaştırır.			
8	Gazların sıkışma/genleşme sürecindeki davranışlarını sorgular,			
9	Belli miktarda gazın basıncı sabitken sıcaklık – hacim ilişkisini irdeler			
10	Belli miktarda gazın hacmi sabitken sıcaklık – basınç ilişkisini irdeler.			
11	Belli sıcaklıkta bir gazın sabit basınç altında mol sayısı-hacim ilişkisini açıklar.			
12	Belli miktarda gazın sabit sıcaklıkta basınç- hacim ilişkisini irdeler			
13	Belli miktarda gazın sabit sıcaklıkta basınç- hacim ilişkisini irdeler(Açık hava basıncı)			
14	Belli miktarda gazın sabit sıcaklıkta basınç- hacim ilişkisini irdeler.(Açık hava basıncı)			
15	Belli miktarda gazın sabit sıcaklıkta basınç- hacim ilişkisini irdeler(Açık hava basıncı)			
16	Gazların genel özelliklerini kavrayabilme(Difüzyon)			
17	Gazların hangi hallerde ideallikten uzaklaştığını fark eder.			
18	Belli sıcaklıkta bir gazın sabit hacim altında mol sayısı-basınç ilişkisini açıklar.			
19	İdeal gaz denklemini kullanarak bir gazın basıncı kütlesi, mol sayısı, hacmi, yoğunluğu ve sıcaklığı ile ilgili hesaplamaları yapar.			
20	Gaz kanunlarını kavrayabilme. Gazların difüzyonu ile ilgili hesaplama yapar.			

APPENDIX D

GASES CONCEPT TEST-I
GAZLAR KAVRAM TESTİ-I

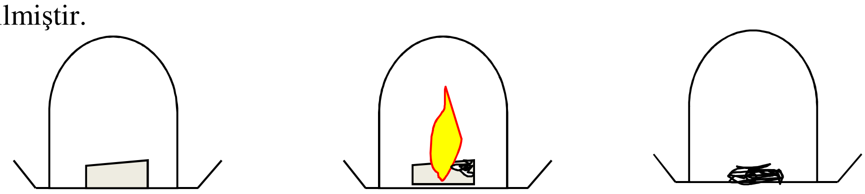
Adı Soyadı:
Sınıfı:
Aşağıda gazlar konusu ile ilgili 20 adet soru bulunmaktadır. Her bir soruyu okuyup size en uygun olan seçeneği işaretleyiniz. Bu test “gazlar ” konusu ile ilgili genel bakış açınızı belirlemek amacıyla hazırlandığı için her soruyu cevaplamaya çalışınız.

1. Hava ile dolu bir şırınganın ucu kapatılmakta ve şırınganın pistonu havayı sıkıştıracak şekilde itilmektedir. Bu sıkıştırma sonucunda havayı oluşturan moleküllere ne olur?



a) Moleküller birbirine yapışır.
b) Moleküller arasındaki mesafe azalır.
c) Sıkıştırılan moleküllerin hareketi durur.
d) Moleküller küçülürler.
e) Moleküllerin hepsi şırınganın ucunda toplanır.

2. Aşağıda verilen şekilde Durum 1’de bir parça kağıt cam fanusun içine konmaktadır. Durum 2’de kağıt yakılmakta ve Durum 3’te küller oluşmaktadır. 1, 2 ve 3 durumlarında her şey tartıldığına göre, sonuç aşağıdakilerden hangisinde doğru verilmiştir.



Kağıt **1**   **2**   Kül **3**

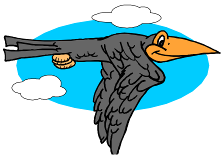
a) Durum 1 daha büyük kütleye sahiptir.
b) Durum 2 daha büyük kütleye sahiptir.
c) Durum 3 daha büyük kütleye sahiptir.
d) 1 ve 2 aynı ağırlığa sahip ve 3’ten ağırdır.
e) Hepsi aynı kütleye sahiptir.

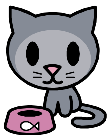
3. Kapalı bir kapta sıvı halden de gaz hale geçen bir madde için aşağıdaki özelliklerden hangisi değişir?

I. Taneciklerin boyutu
II. Moleküller arası uzaklık
III. Moleküllerin toplam kütlesi

4. Aşağıdaki resimlerin hangisinde gaz basıncı(açık hava basıncı) vardır?

a)Yalnız I b)Yalnız II c)Yalnız III d)II ve III e)I,II ve III


I. Kuş uçuyor.

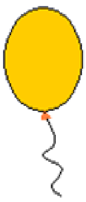

II. Kedi duruyor.

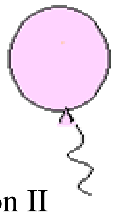

III.Yel değirmeni dönüyor.

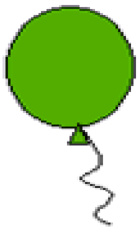

IV.Yaprak savruluyor.

a)Yalnız I b)Yalnız III c)I ve III d)I, III, ve IV e)Hepsi

5. Özdeş üç esnek balona farklı miktarda hava üfleniyor. I. balona çok az, ikinci balona biraz daha fazla ve III. balona en fazla hava üfleniyor. Bu üç balonun basınçlarını kıyaslayınız.


Balon I

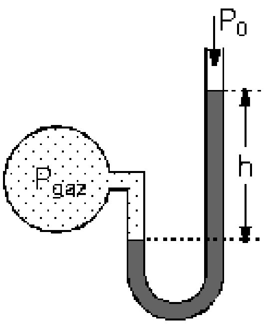

Balon II


Balon III

a) Balon I> Balon II > Balon III
b) Balon III > Balon II > Balon I
c) Balon III > Balon I > Balon II
d) Balon I = Balon II =Balon III
e) Balon II > BalonIII >Balon I

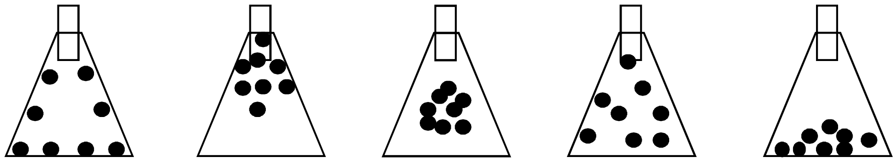
6. Şekildeki manometre ile gazın basıncı ölçülmek isteniyor. Aşağıdakilerden hangisi bulunacak değeri <u>etkilemez?</u>

7. <u>25 °C deki</u> bir kap içerisinde bulunan <u>havayı oluşturan gaz taneciklerinin dağılımını</u>



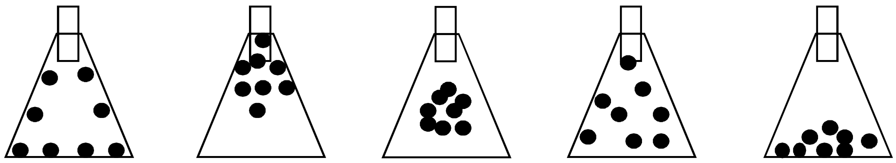
a) Bulunulan enlem
b) Ortamın sıcaklığı
c) U-borusunun çapı
d) Deniz seviyesinden yükseklik
e) Açık hava basıncı

ifade eden en uygun şekil aşağıdakilerden hangisidir?



a) b) c) d) e)

8. 25 ^{o}C deki kap su banyosu yardımıyla ısıtılıp, içerisindeki taneciklerin sıcaklığının 60^{0}C'a gelmesi sağlanıyor.
60 ^{o}C de kap içerisinde havayı oluşturan gaz taneciklerinin dağılımını ifade eden en uygun şekil aşağıdakilerden hangisidir?



a) b) c) d) e)

9. Üflenerek biraz şişirilip ağzı iple bağlanmış elastik bir balon, bulunduğu ortamdan alınarak

I. Aynı basınçta daha soğuk
II. Aynı sıcaklıkta, yükseltisi fazla
III. Aynı sıcaklıkta havası boşaltılmış

ortamlardan hangilerine konulduğunda, balonun hacminin artması beklenir?

a) Yalnız I b) Yalnız II c) Yalnız III d) I ve II e) II ve III

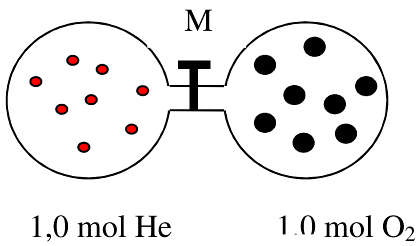
10. Gazların özellikleri ile ilgili aşağıdakilerden hangisi yanlıştır?

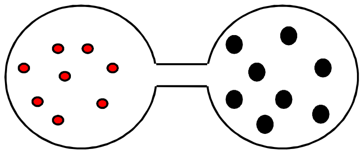
a) Aynı sıcaklıkta bütün gazların ortalama kinetik enerjileri aynıdır.
b) Gaz basıncı, gazın moleküllerinin içerdiği atom sayısına ve cinsine bağlıdır.
c) Gazlar tanecikli yapıya sahiptir.
d) Gaz basıncı, birim hacimdeki tanecik sayısına bağlıdır.
e) Gazlar, bulundukları kabın her tarafına yayılır.

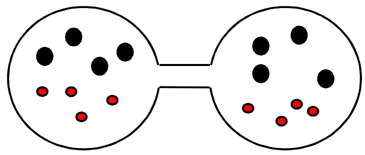
11. Aşağıdakilerden hangisi gazlarının sıkıştırıla bilirliğine örnek <u>değildir?</u>

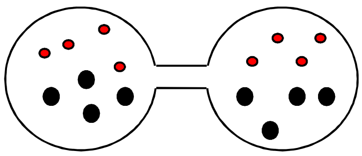
a) Deodorantlar
b) Böcek ilaçları
c) Mutfak tüpü
d) Diş macunu
e) Yangın söndürme tüpü

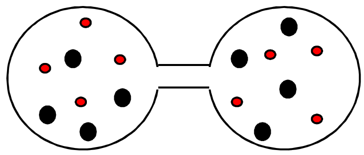
12. Oda koşullarında aşağıdaki sistemde bulunan kaplar M musluğu ile birbirine bağlanmıştır. 1. kapta 1 L hacimde 1 mol He gazı, 2. kapta ise 1 L hacimde 1 mol O_2 gazı bulunmaktadır. M musluğu açıldığında gaz karışımının son halini gösteren en uygun çizim aşağıdakilerden hangisidir?(O:16, He:4)

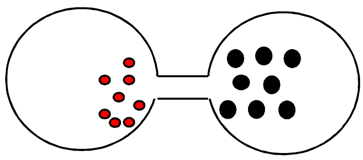


a)


b)


c)


d)


e)


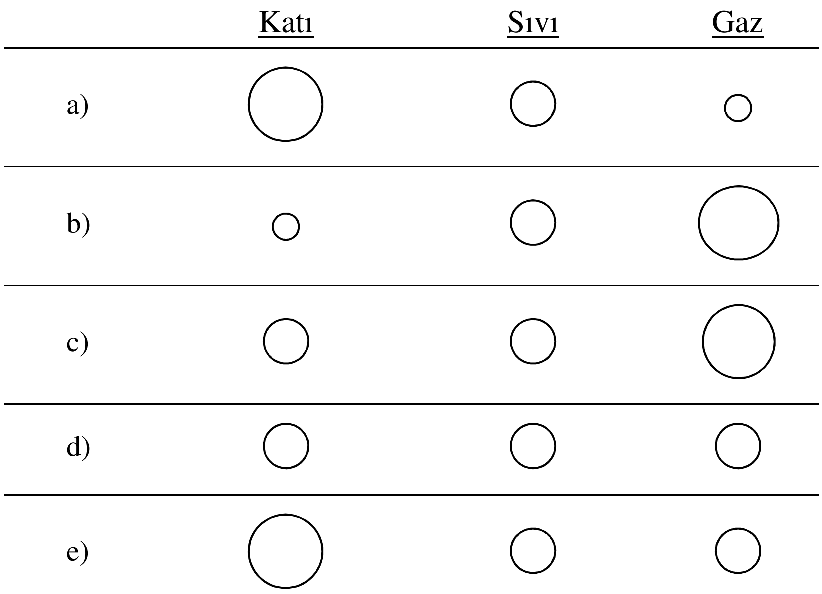
13. Hacmi sabit olan kapalı bir kapta bir miktar Oksijen gazı bulunmaktadır. <u>Sabit sıcaklıktaki</u> bu kaptan bir miktar oksijen çıkışı olduğunda aşağıdaki açıklamalardan hangisi doğru olur?

a) Kabın içindeki oksijen molekülleri yavaşlamıştır.
b) Kabın içinde daha az molekül kaldığı için kabın duvarlarında daha az çarpışma olacaktır.
c) Kapta kalan oksijen moleküllerinin her biri kabın duvarlarına daha az kuvvet uygular.
d) Kapta daha az molekül kaldığı için bu moleküller kabın hacmini tamamen dolduramaz.
e) Basınç yalnızca sıcaklık ve hacme bağlıdır. Sıcaklık ve hacim sabit olduğu için basınç değişmez.

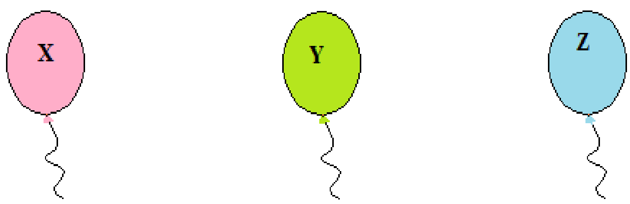
14. Gazların basıncı ile ilgili aşağıdakilerden hangisi doğrudur?

a) Gaz basıncı gazların ısıtılması ile oluşur.
b) Daha ağır gazlar daha fazla basınç uygular.
c) Gaz basıncı, birim hacimdeki tanecik sayısına bağlıdır.
d) Gaz basıncı gazların üzerine uygulanan etkiye verdikleri tepkidir.
e) Gazlar bulundukları kabın her yerine aynı basıncı yaparlar.

15. Aşağıdaki seçeneklerden hangisi H_2O bileşiğinin katı sıvı ve gaz halindeki taneciklerinin birbirlerine göre büyüklüğünü en iyi şekilde göstermektedir?



16. Üç özdeş elastik balondan biri X, biri Y, diğeri ise Z gazı ile eşit hacimli olacak şekilde, oda koşullarında doldurulmuştur. Aynı ortamda, bir süre sonra, gazların balon çeperlerinden sızması nedeniyle balonların hacimleri (V) değişmiş ve $Vx < Vy < Vz$ olmuştur.



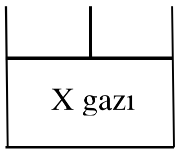
Buna göre balonlardaki gazlar için aşağıdakilerden hangisi doğrudur?

a) Son durumda X in mol sayısı Y den büyüktür.
b) Yayılma(difüzyon) hızı en büyük olan X'dir.
c) Molekül kütlesi en büyük olan X'dir.
d) Yayılma hızı(difüzyon) en büyük olan Z'dir.
e) Molekül kütlesi en büyük olan Y'dir.

17. Bir gazı oluşturan taneciklerin arasında ne vardır?

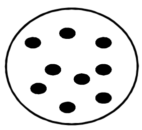
a) Su buharı
b) Hava
c) Yabancı maddeler(toz, kir gibi)
d) Başka gazlar
e) Hiçbirşey yoktur.

18. Şekilde verilen sistemin pistonu sabit sıcaklıkta aşağıya doğru itilirse X gazı ile aşağıdakilerden hangisi doğrudur?

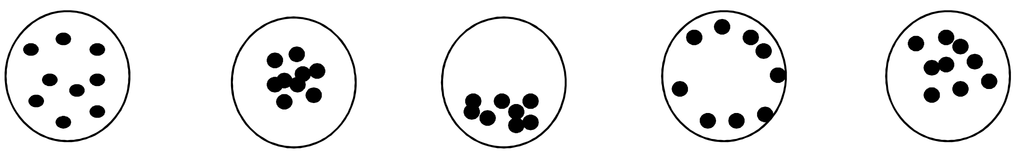


a) Gaz sıkıştırılıp, birim zamanda birim yüzeye çarpan molekül sayısı (basınç) artacağından moleküllerin hızı da artar.
b) Gaz molekülleri birbirine yaklaşıp hacim azalacağından moleküllerin büyüklüğü azalır.
c) Hacim azaldığı için basınç azalır.
d) Gaz molekülleri birbirine yaklaşır, hacim azalır ve birim zamanda basınç artar.
e) Gaz sıkıştırılınca hacim azalır ve ortalama molekül hızı azalır.

19. Aşağıdaki şekil 20 ^{o}C ve 3 atm basınçta Hidrojen gazı ile dolu silindirin enine kesitidir. Noktalar, tanktaki bütün Hidrojen moleküllerinin dağılımını temsil etmektedir.



Sıcaklık -5 C ye düşürüldüğünde aşağıdaki şekillerden hangisi kapalı çelik tanktaki Hidrojen moleküllerinin olası dağılımını göstermektedir?



a) b) c) d) e)

20. Havaalanından bir paket cips alan Deniz, uçağa binip havalandıklarında cips paketinin açmak üzere iken paketin şişkinleştiğini fark etmiştir. Bunun nedeni aşağıdakilerden hangisi olabilir?

a) Uçak yükseldikçe açık hava basıncı artacağından cips paketinin içindeki basınç azalır.
b) Uçak yükseldikçe açık hava basıncı azalacağından, iç basıncı azaltmak için cips paketinin hacmi artar.
c) Uçak yükseldikçe açık hava basıncı artacağından, iç basıncı azaltmak için cips paketinin hacmi azalır.
d) Uçak yükseldikçe açık hava basıncı azalacağından iç basıncı azaltmak için cips paketinin hacmi azalır.
e) Uçak yükseldikçe cips paketinin içindeki taneciklerin sıcaklığı artar ve paketin hacmi artar.

GCT-I Answer KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B	E	B	E	B	C	D	D	B	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
D	D	B	C	D	B	E	D	A	C

APPENDIX E

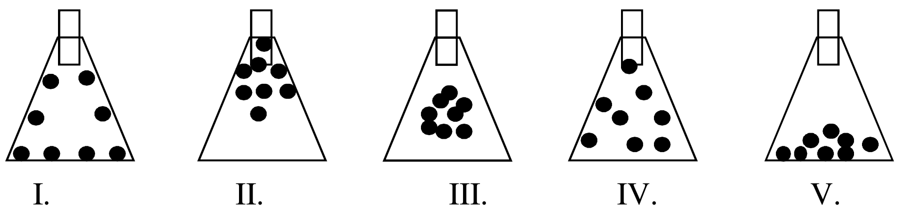
GASES CONCEPT TEST-II
GAZLAR KAVRAM TESTİ-II

Adı Soyadı:

Sınıfı:

Aşağıda gazlar konusu ile ilgili 20 adet soru bulunmaktadır. Her bir soru iki aşamalıdır. Her soruyu okuyup önce size en uygun cevap seçeneğini daha sonra o seçeneği seçme nedeninizi işaretleyiniz.
Bu test gazlar konusu ile ilgili bakış açınızı belirlemek amaçlı olduğu için her soruya cevap vermeye çalışın.

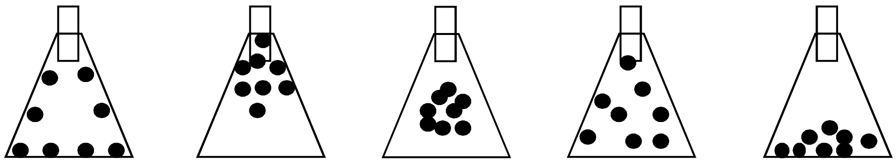
1. <u>25 ^{o}C deki</u> bir kap içerisinde bulunan havayı oluşturan gaz taneciklerinin dağılımını ifade eden en uygun şekil aşağıdakilerden hangisidir?



Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

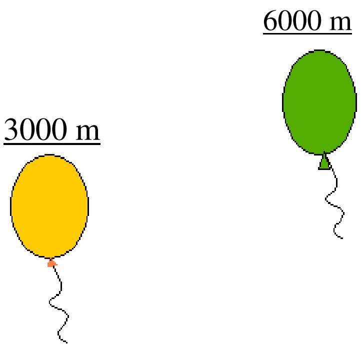
a) Havayı oluşturan gaz tanecikleri hafiftir ve kabın üst kısımlarında toplanır.
b) Gaz tanecikleri sıvılar gibi kabın alt kısımlarında toplanır.
c) Gaz tanecikleri kabın şeklini alarak kabın çeperlerinde toplanır.
d) Gaz tanecikleri homojen olarak bulundukları ortama yayılırlar.
e) Gaz tanecikleri büzüşür ve bir araya toplanır.

2. 25 ^oC deki kap su banyosu yardımıyla ısıtılıp, içerisindeki taneciklerin sıcaklığının 60^0C'a gelmesi sağlanıyor.
60 ^oC de kap içerisinde havayı oluşturan gaz taneciklerinin dağılımını ifade eden en uygun şekil aşağıdakilerden hangisidir?



Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Soğuktan sıcağa geçen gaz tanecikleri arası çekim kuvveti artar ve bir araya toplanır.
b) Sıcaklık arttığında gazlar gaz taneciklerinin kütlesi azalır ve kabın üst kısımlarında toplanır.
c) Gazlar her sıcaklıkta bulundukları kaba homojen olarak dağılırlar.
d) Sıcaklık arttığında gaz taneciklerinin kütlesi artar ve kabın alt kısımlarında toplanır.
e) Her bir gaz taneciğinin boyutu küçülerek, büzüşür ve bir araya toplanır.



3. Yukarıdaki Helyum dolu iki özdeş esnek balonun hacmi 20 L'dir. Bu balonlar açık havada serbest bırakılmış ve bir süre sonra biri 3000 m yükseğe çıkarken diğerinin 6000 m yükseğe çıktığı gözlenmiştir.
Aynı sıcaklıktaki bu balonlardan hangisinin hacmi daha büyüktür?

I. 3000 m'de ki balon
II. 6000 m'de ki balon
III. İki balonda aynı hacimdedir.

Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Balon yükseldikçe açık hava basıncı azalacağından iç basıncı azaltmak için hacim artar.
b) Balon yükseldikçe açık hava basıncı artacağından, iç basıncı azaltmak için hacim azalır.
c) Balon yükseldikçe açık hava basıncı artacağından iç basıncı azaltmak için hacim artar.
d) İç basınç daima dış basınca(açık hava basıncına) eşit olduğu için her iki balonda aynı hacimdedir.
e) Balon yükseldikçe açık hava basıncı azalacağından balonun içindeki hava basıncı azalır.

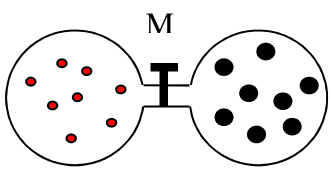
4. Havaalanından bir paket cips alan Deniz, uçağa binip havalandıklarında cips paketinin açmak üzere iken paketin hacmiyle ilgili ne gözlemlemiş olabilir?

I. Arttığını
II. Azaldığını
III. Değişmediğini

Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

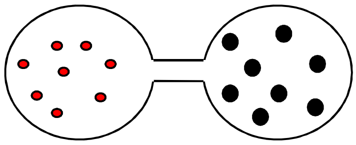
a) Uçak yükseldikçe açık hava basıncı azalacağından, iç basıncı azaltmak için cips paketinin hacmi artar.
b) Uçak yükseldikçe açık hava basıncı azalacağından cips paketinin içindeki basınç azalır.
c) Uçak yükseldikçe açık hava basıncı artacağından, iç basıncı azaltmak için cips paketinin hacmi azalır.
d) Uçak yükseldikçe açık hava basıncı artacağından iç basıncı azaltmak için cips paketinin hacmi azalır.
e) Uçak yükseldikçe dış basınç iç basınç dengesi değişmeyeceğinden paketin hacmi değişmez.

5. Oda koşullarında aşağıdaki sistemde bulunan kaplar M musluğu ile birbirine bağlanmıştır. 1. kapta 1 L hacimde 1 mol He gazı, 2. kapta ise 1L hacimde 1 mol O_2 gazı bulunmaktadır. M musluğu açıldığında gaz karışımının son halini gösteren en uygun çizim aşağıdakilerden hangisidir?(O:16, He:4)

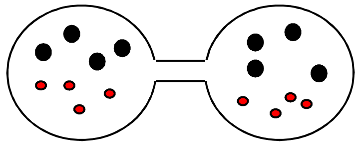


1,0 mol He 1,0 mol O_2

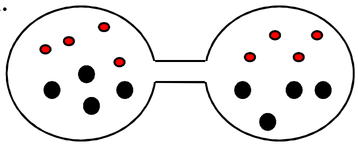
I.



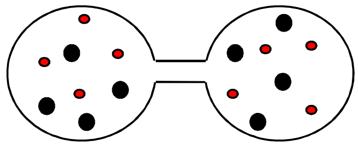
II.



III.



IV.



Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Gaz molekülleri bulundukları kaba homojen bir şekilde dağıldıkları için ikisi de birer litre hacim kaplar.
b) Oksijenin mol kütlesi büyük olduğundan daha çok yer kaplar.
c) Normal koşullar altında 1 mol ideal gaz 22,4 L hacim kapladığından her iki gaz 22,4 litre hacim kaplar.
d) Gaz molekülleri bulundukları kaba homojen bir şekilde dağıldıkları için ikisi birlikte iki litre hacim kaplar.
e) Helyum oksijenden 4 kat daha hızlı hareket ettiğinden, 4 kat fazla hacim kaplar.

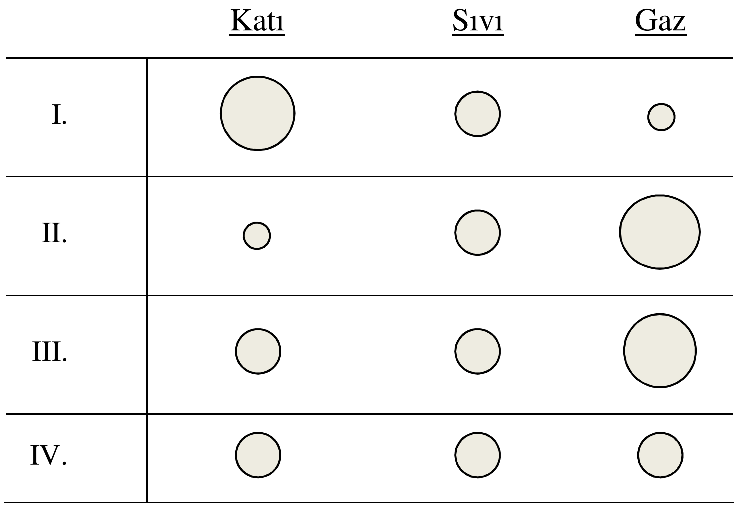
6. Kapalı bir kapta sıvı halden de gaz hale geçen bir madde için aşağıdaki özelliklerden hangisi değişir?

I. Taneciklerin boyutu
II. Moleküller arası uzaklık
III. Moleküllerin toplam kütlesi

Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Madde sıvı halden gaz hale geçerken molekülleri birbirine gelişigüzel ve daha çok çarptığı için gaz moleküllerinin boyutu değişir.
b) Gaz molekülleri enerji aldığı için genişler ve moleküller arası uzaklık artar.
c) Gaz molekülleri bulunduğu kabın şeklini aldığı için moleküllerin şekli ve büyüklüğü değişir.
d) Hal değişimi sırasında sıcaklık sabittir. Alınan enerji tanecikler arası uzaklığı arttırır.
e) Gaz tanecikleri sıvı taneciklerinden daha hafif olduğu için moleküllerin toplam kütlesi azalır.

7. Aşağıdaki seçeneklerden hangisi H_2O bileşiğinin katı sıvı ve gaz halindeki taneciklerinin birbirlerine göre büyüklüğünü en iyi şekilde göstermektedir? (Her dairenin bir H_2O molekülünü gösterdiği varsayılmıştır.)



Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Gazlarda tanecikler arası boşluk katı ve sıvı halden çok daha fazla olduğu için gaz taneciklerinin boyutu daha büyüktür.

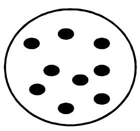
b) Gazların ağırlığı olmadığı için, gaz fazından katı fazına geçildikçe her bir taneciğin büyüklüğü artar.

c) Katı ve sıvı fazda molekül büyüklüğü aynı iken gaz fazda hacim büyük olduğu için tanecik boyutu da en büyüktür.

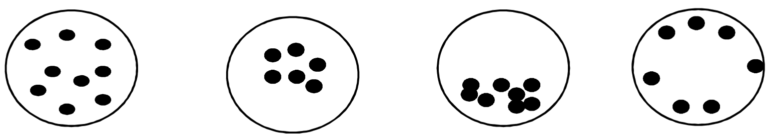
d) Gazlar katı ve sıvılardan hafiftir. Bu nedenle gaz fazında tanecikler en küçük haldedir.

e) Bir maddenin taneciklerinin boyutu katı sıvı ve gaz halinden bağımsızdır, taneciklerin elektron ve proton sayısına göre atom çapına bağlıdır.

8. Aşağıdaki şekil 20 °C ve 3 atm basınçta Hidrojen gazı ile dolu silindir şeklindeki çelik bir tankın enine kesitidir. Noktalar, tanktaki bütün Hidrojen moleküllerinin dağılımını temsil etmektedir.



Sıcaklık -5 C ye düşürüldüğünde aşağıdaki şekillerden hangisi kapalı çelik tanktaki Hidrojen moleküllerinin olası dağılımını göstermektedir? (Hidrojen gazının kaynama noktası -243 C' dir.)



I. II. III. IV.

Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Sıcaktan soğuğa geçen gaz tanecikleri büzüşerek bir araya toplanır.
b) Sıcaklık azaldığında gazların hareket özelliği azalır.
c) Gazlar her sıcaklıkta bulundukları kaba homojen olarak dağılırlar.
d) Sıcaklık azaldığında gaz taneciklerinin kütlesi artar ve kabın dibinde toplanırlar.
e) Her bir gaz taneciğinin boyutu küçülerek moleküller arası mesafe azalır.

9. Bir balon 22 ^{o}C de, 760 mm Hg atmosfer basıcında 3 L Helyum ile dolduruluyor. Hava sıcaklığının 31 ^{o}C olduğu bir yaz günü balon evin penceresinden uçup gidiyor. Eğer basınç sabit kalırsa balonun hacmi ne olur?

I. 6,9 L II. 3,1 L III. 3 L IV.2,9 L V. Hiçbiri

Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) İdeal gaz denklemine göre basınç ve hacim ters orantılıdır.
b) İdeal gaz denklemine göre V-T ters orantıdır. Sıcaklık artarsa, basıncın ve mol sayısının sabit olduğu durumda hacim azalır.
c) Gazlar yalnızca oda sıcaklığında ideal davrandığından ikinci durumdaki hacim hakkında bir şey söylenemez.
d) Basıncın sabit olduğu durumda, sıcaklık artığında taneciklerin kinetik enerjileri de artar ve taneciklerin kapladığı hacim artar.
e) İdeal gazlar kimyasal reaksiyona girmediğinden hacim değişmez.

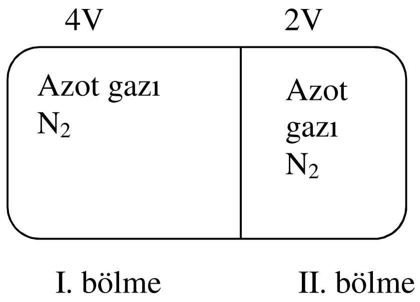
10. Hacmi sabit olan kapalı bir kapta bir miktar Oksijen gazı bulunmaktadır. Sabit sıcaklıktaki bu kaptan bir miktar oksijen çıkışı olduğunda kabın içindeki basınç;

I. Azalır
II. Artar
III. Değişmez

Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Kabın içindeki oksijen molekülleri yavaşlamıştır.
b) Kabın içinde daha az molekül kaldığı için kabın duvarlarında daha az çarpışma olacaktır.
c) Kapta kalan oksijen moleküllerinin her biri kabın duvarlarına daha az kuvvet uygular.
d) Kapta daha az molekül kaldığı için bu moleküller kabın hacmini tamamen dolduramaz.
e) Basınç yalnızca sıcaklık ve hacme bağlıdır. Sıcaklık ve hacim sabit olduğu için basınç değişmez.

11. Aşağıdaki şekilde hareketli pistonla ayrılmış bir silindir görülmektedir. Pistonun her iki bölmesinde de Azot gazı bulunmaktadır. İlk bölmedeki Azot gazı 4 V hacim kaplarken ikinci bölmedeki Azot gazı 2V hacim kaplamaktadır. Sıcaklığın sabit olduğu koşullarda verilen bu bilgilerden yola çıkarak 2. bölmedeki Azot gazının mol sayısı "n" ise birinci bölmedeki azot gazının mol sayısı aşağıdakilerden hangidir?



I. n

II. 2n

III. n/2

IV. Verilen bilgi yetersizdir.

Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Her iki bölmedeki gazların cinsi aynı olduğu için mol sayıları aynıdır.
b) Birinci bölmedeki gazın kapladığı hacim büyük olduğundan sabit sıcaklıkta mol sayısı fazladır.
c) Her iki bölmedeki moleküllerin ortalama kinetik enerjileri eşit olduğundan mol sayıları aynıdır.
d) Her iki bölmedeki gazın basıncı hakkında bilgi sahibi olmadan mol sayısı hakkında yorum yapılamaz.
e) İkinci bölmedeki gazın hacmi küçük olduğundan basıncı fazladır. Dolayısı ile birim zamanda birim yüzeye çarpan tanecik sayısı fazladır.

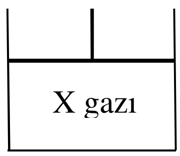
12. Şekilde verilen sistemin pistonu sabit sıcaklıkta aşağıya doğru itilirse X gazı ile ilgili özelliklerden hangisi değişir?

I. Birim zamanda birim yüzeye çarpan molekül sayısı

II. Ortalama molekül hızı

III. Sıcaklık

IV. Moleküllerin büyüklüğü

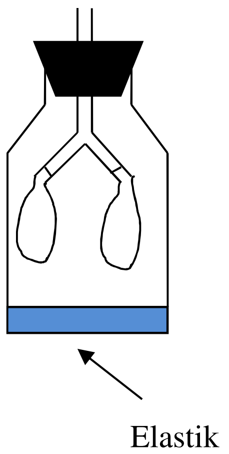


Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Gaz sıkıştırılıp basınç artacağından moleküllerin hızı da artar.
b) Gaz molekülleri birbirine yaklaşıp hacim azalacağından moleküllerin büyüklüğü azalır.
c) Sıcaklık artar ve böylece taneciklerin kinetik enerjisi artar.
d) Gaz molekülleri birbirine yaklaşır, hacim azalır ve birim zamanda birim yüzeye çarpan molekül sayısı artar.
e) Gaz sıkıştırılınca hacim azalır ve ortalama molekül hızı azalır.

Aşağıdaki şekilde ağzı kapalı geniş bir kavanoz ve içine yerleştirilmiş iki elastik balon görülmektedir. Şişenin alt kısmı elastik bir zarla kapatılmıştır. Balonlar bir adet ince boru ile atmosfere açıktır. Aşağıda verilen **13. 14. ve 15**. soruları bu bilgileri göz önünde bulundurarak cevaplayınız.

13. Şekildeki durumda balonun içindeki hava basıncını, şişenin içindeki hava basıncı ve atmosfer basıncı ile kıyaslayınız.

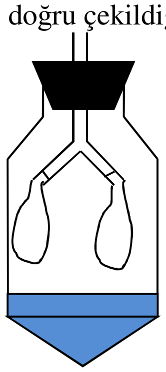


I. Atmosfer basıncı > Şişenin basıncı > Balonun basıncı
II. Şişenin basıncı = Atmosfer basıncı = Balonun basıncı
III. Atmosfer basıncı > Şişenin basıncı = Balonun basıncı
IV. Şişenin basıncı > Atmosfer basıncı > Balonun basıncı

Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Dışarıdan bir etki olmadığı sürece, dengedeki bir sistemde iç basınç daima atmosfer basıncına eşit olduğundan üçünün basıncı eşittir.
b) Atmosferdeki hava molekülleri çok daha fazla olduğu için atmosfer basıncı her ikisinden de büyüktür.
c) Atmosferdeki moleküllerin sayısı şişenin içindeki molekül sayısından, şişedekilerde balondakilerden fazla olduğu için basınçların büyüklüğü de böyle sıralanır.
d) Şişe cam olduğu içindeki basınç hem atmosfer basıncından hem de balonların basıncından büyüktür.
e) Atmosferdeki hava molekülleri yalnızca hareket halindeki cisimlere basınç uygulayacağından birim hacimde şişe ve balonun içindeki moleküllere göre daha az basınç uygular.

14. Şişenin alt kısmındaki elastik zar şekildeki gibi aşağı doğru çekildiğinde ne gözlemlemeyi beklersiniz?



I. Balonlar şişer.
II. Balonların hacmi azalır.
III. Hiç bir değişiklik gözlenmez.

Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Hacim azaldığı için şişenin iç basıncı artar. Açık hava basıncı -iç basınç farkından dolayı balonların hacmi de azalır.
b) Cam şişe içindeki basınç ile Açık hava basıncı dengeleneceği için hiçbir değişiklik gözlenmez.
c) Yukarıdan aşağıya doğru etkiyen açık hava basıncı balonların şişmesine neden olur.
d) Hacim arttığı için şişenin iç basıncı azalır. Açık hava basıncı-iç basınç farkından dolayı balonlara hava girişi olur, balonlar şişer.
e) Atmosfer basıncı gaz molekülerini balonların içine doğru iter ve balonlar şişer.

15. Aşağıda belirtilen şartların hangisinde balon patlayabilir?

I. Sistem atmosfer basıncın daha yüksek olduğu bir yere götürülürse
II. Şişenin içindeki hava tamamen boşaltılırsa
III. Şişenin içine hava eklenirse
IV. Şişenin hava girişi kapatılıp sistem ısıtılırsa

Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Atmosfer basıncının yüksek olması şişe içindeki basıncı da artırır ve balonlar patlayabilir.
b) Şişedeki hava boşalırsa atmosfer yalnızca balona basınç uygular, hacim artar ve balonlar patlayabilir.
c) Şişenin içine hava eklenirse iç basınç artar. Balonların hacmi artar ve patlayabilir.
d) Şişenin içindeki hava çekilirse iç basınç artar. Basınç farkından dolayı balonlar patlayabilir.
e) Şişe içinde sıcaklıkla beraber basınç artar. Balonlar elastik olduğundan ısınan gaz tanecikleri belli bir hacme kadar genişler sonrasında balonlar patlayabilir.

16. Üç özdeş elastik balondan biri X, biri Y, diğeri ise Z gazı ile eşit hacimli olacak şekilde, oda koşullarında doldurulmuştur. Aynı ortamda, bir süre sonra, gazların balon çeperlerinden sızması nedeniyle balonların hacimleri (V) değişmiş ve $V_x < V_y < V_z$ olmuştur.

Buna göre balonlardaki gazlar için aşağıdakilerden hangisi doğrudur?

I. Son durumda X in mol sayısı Y den büyüktür.
II. Yayılma hızı en büyük olan X'dir.
III. Molekül kütlesi en büyük olan X'dir.
IV. Yayılma hızı en büyük olan Z'dir.

Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Son durumda hacmi en küçük olan X balonu ise X balonundaki taneciklerin mol sayısı Y den büyüktür.
b) Son durumda hacmi en büyük olan Z balonu ise, Z balonundaki taneciklerin yayılma hızı daha büyüktür.
c) Gazların yayılma hızı molekül kütleleri ile doğru orantılı olduğundan mol kütlesi en büyük olan X'dir.
d) Molekül kütlesi küçük olan tanecikler, büyük olanlara göre daha hızlı hareket edeceğinden X in yayılma hızı en büyüktür.
e) Z balonunun hacmi en büyük olduğundan yayılma hızı en büyüktür.

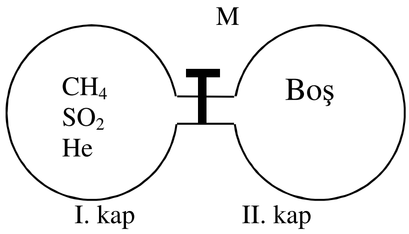
17. Aşağıdaki kapların üçünde de bir gerçek gaz olan H_2 bulunmaktadır. Bu gazlardan hangisi ideale en yakındır?

I.	II.	III.
P=1 atm T=0 ^{o}C	P=1 atm T=25 ^{o}C	P=0,1 atm T=25 ^{o}C

Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Yüksek sıcaklık ve düşük basınçta kinetik enerjisi artan taneciklerin moleküller arası çekim kuvveti azalır ve gaz ideale yaklaşır.
b) Yüksek basınçta moleküller birbirine yaklaşır ve gerçek gazlar ideal gaza benzer davranış gösterir.
c) Bir gazın ideal gaz olması o gazın cinsine bağlıdır.
d) Düşük sıcaklık ve yüksek basınçta kinetik enerjisi artan gaz molekülleri birbirinden uzaklaşır ve ideale yaklaşır.
e) 0 atm basınca en yakın gaz ideal davranır. Çünkü bu basınçta gaz tanecikleri hareket etmez.

18. Aşağıdaki şekilde hacimleri eşit olan kaplar M musluğu ile birbirine bağlanmıştır.



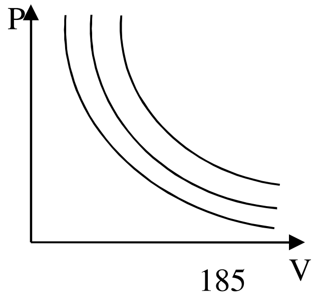
1. kaptaki gazların mol sayıları eşittir. Musluk kısa bir süre için açılıp kapatılıyor. Buna göre aşağıdaki bilgilerden hangisi doğrudur?(He:4, CH_4:16, SO_2: 64)

I. 2. kaptaki miktarı(mol sayısı) en fazla olan SO_2 dir.
II. 1. kapta kütlesi en fazla olan He dur.
III. 1. kaptaki gazların kısmi basınçları $PHe<PCH_4<PSO_2$
IV. 1. kaptaki gazların kısmi basınçları $PHe = PCH_4 = PSO_2$
V. Verilen bilgi yetersizdir.

Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Molekül ağırlığı küçük olan He gazı CH_4'ten, CH_4 gazı da SO_2 den hızlı hareket eder. Buna göre 1. kaptaki mol sayıları $nHe<nCH_4<nSO_2$ olacağından kısmi basınçları da $PHe<PCH_4<PSO_2$ olur.
b) Gazların mol sayıları eşit olduğundan son durumda 1. kaptaki kısmi basınçları da eşittir.
c) Gaz taneciklerinin hareketi sıcaklığa bağlı olduğundan sıcaklığı bilmeden gaz taneciklerinin ikinci kaba geçip geçmeyeceği bilinemez.
d) Gazların yayılma hızı mol sayıları ile doğru orantılı olduğundan SO_2 gazı ikinci kapta daha fazladır.
e) Gazların yayılma hızı molekül ağırlıkları ile doğru orantılı olduğundan birinci kaptaki He kütlesi en fazladır.

19. Belirli bir gaza ilişkin yapılan üç deneyde basınç-hacim grafiği yandaki gibi bulunmuştur.
Bu üç deneyle ilgili verilen bilgilerden hangisi/leri doğrudur?



I. Deneyler farklı sıcaklıkta yapılmış olabilir.
II. Deneylerde farklı miktarda gaz kullanılmış olabilir.
III. Deneylerde hem sıcaklık hem de miktarlar farklı olabilir.
IV. Hepsi doğrudur.

Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Hacim-basınç ilişkisi mol sayısı ve sıcaklıktan bağımsızdır.
b) Deneyler farklı sıcaklıkta yapıldığında kinetik enerjisi değişen taneciklerin P-V değerleri değişir.
c) PV=k bağıntısındaki “k “sabiti hem sıcaklığa hem de mol sayısına bağlı olarak değişir.
d) Yalnızca gazın miktarı değiştirilirse kabın çeperlerine uygulanan basınç ve dolayısı ile hacim değişir.
e) P-V değerlerinin değişmesi hem sıcaklığın artması aynı zamanda da mol sayısının değişmesi ile mümkündür.

20. SO_3 gazının 40 saniyede geçtiği borudan aynı koşullarda Ne gazı kaç saniyede geçer?(S:32, O:16, Ne:20)
I. 40 sn’den fazla
II. 40 sn
III. 40 sn’den az

Aşağıdaki açıklamalardan hangisi cevabınızın nedenini en uygun şekilde açıklar?

a) Gazların yayılma hızı molekül kütleleri ile doğru orantılıdır.
b) Molekül kütlesi küçük olan Ne gazı, büyük olan SO_3 gazına göre daha hızlı hareket eder.
c) Mol sayıları aynı ise iki gazda aynı hıza sahiptir.
d) Molekül kütlesi büyük olan SO_3 gazı, küçük olan Ne gazından daha hızlı hareket eder.
e) Mol sayıları aynı ise SO_3 daha hızlı hareket eder.

GCT-II Answer KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
IV-D	IV-C	II-A	I-A	IV-D	II-D	IV-E	I-C	II-D	I-B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
II-B	I-D	II-A	I-D	IV-E	II-D	III-A	III-A	III-C	III-B

APPENDIX F

ATTITUDE SCALE TOWARD CHEMISTRY
KİMYA DERSİ TUTUM ÖLÇEĞİ

AÇIKLAMA: Bu ölçekte, Kimya dersine ilişkin tutum cümleleri ile her cümlenin karşısında ***Tamamen Katılıyorum, Katılıyorum, Karasızım, Katılmıyorum, Hiç Katılmıyorum*** olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatle okuduktan sonra kendinize uygun olan tek bir seçeneği işaretleyiniz. Teşekkür Ederim.
Adı Soyadı:
Sınıfı/Numarası:

	Tamamen Katılıyorum	**Katılıyorum**	**Kararsızım**	**Katılmıyorum**	**Hiç katılmıyorum**
1. Kimya çok sevdiğim bir alandır.	○	○	○	○	○
2. Kimya ile ilgili kitapları okumaktan hoşlanırım.	○	○	○	○	○
3. Kimyanın günlük yaşantıda çok önemli yeri yoktur.	○	○	○	○	○
4. Kimya ile ilgili ders problemlerini çözmekten hoşlanırım.	○	○	○	○	○
5. Kimya konularıyla ilgili daha çok şey öğrenmek isterim.	○	○	○	○	○
6. Kimya dersine girerken sıkıntı duyarım.	○	○	○	○	○
7. Kimya derslerine zevkle girerim.	○	○	○	○	○
8. Kimya derslerine ayrılan ders saatinin daha fazla olmasını isterim.	○	○	○	○	○
9. Kimya dersini çalışırken canım sıkılır.	○	○	○	○	○
10. Kimya konularını ilgilendiren günlük olaylar hakkında daha fazla bilgi edinmek isterim.	○	○	○	○	○
11. Düşünme sistemimizi geliştirmede Kimya öğrenimi önemlidir.	○	○	○	○	○
12. Kimya çevremizdeki doğal olayların daha iyi anlaşılmasında önemlidir.	○	○	○	○	○
13. Dersler içerisinde Kimya dersi sevimsiz gelir.	○	○	○	○	○
14. Kimya konularıyla ilgili tartışmalara katılmak bana cazip gelmez.	○	○	○	○	○
15. Çalışma zamanımın önemli bir kısmı Kimya dersine ayırmak isterim.	○	○	○	○	○

APPENDIX G

ARGUMENTATIVENESS SCALE TOWARD ARGUMENTATION

TARTIŞMACI ANKETİ

Bu anket sizlerin tartışmaya ne kadar istekli (yakın) ve uzak olduğunuzu belirlemek için oluşturulmuştur. Ankette 20 cümle verilmiştir. Her bir cümleyi dikkatlice okuduktan sonra, inandığınız ya da düşündüğünüz yalnızca bir seçeneği işaretleyiniz. Bu anketteki soruların doğru veya yanlış cevapları yoktur. Ayrıca anket sonuçlarınız okul idaresine, öğretmenlerinize veya ailenize verilmeyecektir. Cevaplarınızda dürüst ve içten olmanız, çalışmanın amacı için çok önemlidir. Bilimsel bir çalışmaya katkıda bulunduğunuz için **teşekkürler.** (Kutulardan sadece bir tanesine **X** işareti koyabilirsiniz)

	Anket Maddeleri	**Her zaman**	**Sık sık**	**Bazen**	**Nadiren**	**Hiçbir zaman**
1	Bir tartışmada, tartıştığım kişinin benim hakkımda olumsuz bir izlenime kapılmasından endişe duyarım.					
2	Çekişmeli konularda tartışmak zekamı geliştirir.					
3	Tartışmalardan uzak durmayı severim.					
4	Bir konuyla ilgili tartışırken çok istekli olurum ve kendimi enerji dolu hissederim.					
5	Bir tartışmayı bitirdiğim zaman, bir daha başka bir tartışmaya girmeyeceğime kendi kendime söz veririm.					
6	Bir kişiyle tartışmak, benim için çözümden çok problemler yaratır.					
7	Bir tartışmayı kazandığım zaman, güzel duygular hissederim.					
8	Biriyle tartışmayı bitirdiğim zaman, kendimi sinirli ve üzgün hissederim.					
9	Çekişmeli bir konu hakkında iyi bir tartışma yapmaktan hoşlanırım.					

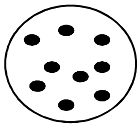
	Anket Maddeleri	**Her zaman**	**Sık sık**	**Bazen**	**Nadiren**	**Hiçbir zaman**
10	Bir tartışma içerisine gireceğimi anladığım zaman, hoş olmayan duygular hissederim.					
11	Bir konu hakkında fikrimi savunmaktan zevk alırım.					
12	Tartışma meydana getirecek bir olayı engellediğim zaman mutlu olurum.					
13	Çekişmeli bir konuda tartışma fırsatını kaçırmak istemem.					
14	Benimle aynı düşüncede olmayan insanlarla bir arada olmayı çok istemem.					
15	Tartışmayı heyecan verici, karşı koyma ve zihinsel bir olay olarak algılarım.					
16	Bir tartışma sırasında etkili fikirleri kendi kendime üretemem.					
17	Çekişmeli bir konuda tartıştıktan sonra kendimi yeniden canlanmış ve mutlu hissederim.					
18	Bir tartışmayı iyi bir şekilde yapacak yeteneğe sahibim.					
19	Bir tartışma içerisine çekilmekten uzak durmaya çalışırım.					
20	Bir konuşmamın tartışmaya dönüşeceğini hissettiğim zaman çok heyecanlanırım.					

APPENDIX H

SEMI-STRUCTURED INTERVIEW QUESTIONS

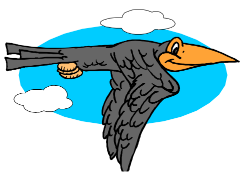
Oda sıcaklığında (25 °C) balon içindeki gaz taneciklerinin dağılımı şekildeki gibi ise;

Taneciklerin 0 °C deki görünümü;

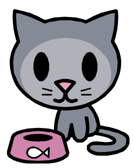


1. Buzlu suda(0 °C) deki su içinde gaz taneciklerinin görünümü nasıl olabilir? Neden? Gerektiğinde çizerek göstermeleri istenir.
2. 90 °C deki su içinde gaz taneciklerinin görünümü nasıldır? Neden? Gerektiğinde çizerek göstermeleri istenir.
3. Gazların difüzyonu deyince ne anlıyorsunuz? Günlük hayattan örnek verebilir misiniz?

4. Aşağıdaki resimlerin hangisinde açık hava basıncı vardır? Neden?



I. Kuş uçuyor.



II. Kedi duruyor.

III.Yel değirmeni dönüyor.

IV.Yaprak savruluyor

5. Açık hava basıncı Everest'in tepesinde mi yoksa eteklerinde mi daha yüksektir? Neden?
6. Bir gazın ideal olması ne demektir? Havadaki oksijen ideal bir gaz mıdır? İdeal gazın özellikleri nelerdir?(Cevap gelmemesi halinde ya da cevabı biraz daha açmak için) Peki gerçek gaz deyince ne anlıyorsunuz?

7. Kapalı bir kap içerisinde 3 mol gaz olduğunu düşünelim. Bu kapalı kap hareketli bir piston sahip olsun. Kabın içine 1 mol daha ekstra gaz ekleyip sıcaklığı da artırırsak ne gibi değişimler gözleriz?

APPENDIX I

CLASSROOM OBSERVATION CHECKLIST

	1 / Hayır	2/ Kısmen	3 / Evet
1. Öğretmen dersin başında herhangi bir giriş etkinliği (tartışma, gösteri deneyi, vs.) yaptı mı?			
2. Öğretmen öğrencilerin ön bilgilerini dikkate aldı mı?			
3. Öğretmen öğrenciler için uygun etkinlik/deney uyguladı mı?			
4. Öğrencilere verilen araştırma soruları sınıf ortamında tartışıldı mı?			
5. Öğrenciler gruplar halinde araştırma sorusunu çözmek için uygun bir yöntem belirledi mi?			
6. Gruplar belirledikleri yöntemi takip ederek araştırma sorusunun cevabını araştırdılar mı?			
7. Öğrenciler deney sırasında gözlemlerini kaydettiler mi?			
8. Gruplar deney sonunda gözlemlerine ve verilerine dayalı olarak iddialar oluşturdular mı?			
9. Gruplar iddialarını desteklemek için deliller oluşturdular mı?			
10. Her grup iddia ve delillerini diğer gruplarla ve öğretmenle paylaştı mı?			
11. Öğrencilerden deney sonrası rapor yazmaları istendi mi?			
12. Gruplar deney sonrası deney raporlarını uygun şekilde doldurdu mu?			
13. Her bir grubun deney raporları farklı gruplara dağıtılıp diğer öğrenciler tarafından incelendi mi?			
14. Gruplara raporlarını tekrar düzenlemeleri için fırsat verildi mi?			
15. Öğrenciler soru sormaya teşvik edildi mi?			
16. Öğretmen, öğrencilere kavramsal sorular sordu mu?			
17. Öğretmen, kavramları doğrudan öğrencilere vermeye çalıştı mı?			
18. Öğretmen öğrencilere dönüt verdi mi?			
19. Bütün öğrenciler aktif olarak derse katıldılar mı?			

APPENDIX J

HANDOUT FOR TEACHERS
Argümantasyona Dayalı Sorgulayıcı Eğitimin Basamakları

1. Adım

Bu adım öğrencilerin dikkatini çekmek amacı ile tasarlanmıştır. Öğrencilere verilen çalışma yapraklarında yürütecekleri araştırma ile ilgili gerekli bilgi kısaca yer almaktadır. Çalışma yaprakları aynı zamanda öğrencilerin cevaplamaları gereken bir araştırma sorusu ve bu araştırma sırasında ihtiyaç duyacakları deney malzemelerinin listesini içermektedir. Öğrencilerden ilk olarak araştırma sorusuna cevap bulabilmek için verilen malzemeleri kullanarak bir deney tasarlamaları istenir. Etkinlik yaprağındaki araştırma sorusuna cevap vermek için nasıl bir deney düzeneği kuracaklarına grup olarak düşünüp karar vermeleri için yaklaşık 15 dk verilir. Buna alternatif olarak, etkinlik öğrencilere bir önceki dersin sonunda dağıtılıp takip eden derse izleyecekleri yönteme karar verip gelmeleri beklenebilir. Her grup, grup olarak hangi yöntemi izleyeceğine karar verip tahtaya ya da çalışma yapraklarına yazar.

2. Adım

Bu adımda öğrencilerden izleyecekleri yönteme karar vermiş olmaları ve bunu tahtaya ya da çalışma yapraklarına yazmaları beklenir. İlk olarak öğrenciler herhangi bir eleştiri ya da yönlendirme olmadan izleyecekleri yöntemi yazarlar/bahsederler. Her grup yönteminden bahsettikten sonra kısa bir sınıf tartışması ile grupların yöntemleri sınıf tarafından değerlendirilir. Bu sırada öğretmenin görevi gerekli yönlendirmelerle öğrencilere kılavuzluk etmektir. Gerekli durumlarda öğretmen çalışma yaprağındaki malzeme listesini öğrencilerin bir ipucu olarak kullanmasını sağlamalıdır. Bu sınıf tartışmasına ayrılacak vakit en fazla 15 dk olarak belirlenmiştir. Öğrenci grubunun seviyesi dolayısı önerilen yöntemler üzerinde ile bazı düzeltmeler ve yönlendirmelere gerek duyulabilir. Bu aşamadan sonra öğrenciler yöntemleri ile araştırma sorusunu test etme aşamasına geçerler. Deney sırasında öğrenciler, not tutmaya ve gözlemlerde bulunmaya yönlendirilir. Öğrenciler aşina olmadıkları bir yöntemle karşılaştıklarından laboratuvar araştırmaları sırasında öğretmene sıkça çeşitli sorular yönlendirebilir. Öğretmen bu sorulara doğrudan cevap vermekten kaçınmalı ve "Neden böyle düşünüyorsun?", gibi öğrenciyi düşündürücü ipuçları vermelidir. Grupların uygun olmayan çözümler ürettiği durumlarda öğretmen yönlendirici sorularla öğrencileri araştırmanın farklı yönlerini düşünmeye sevk etmelidir. Örneğin öğretmen öğrencilere yeni bir deney yapmalarını veya daha fazla kimyasal kullanmalarını önerebilir. Bu adımın sonunda öğrencilerin iddialarını ve kanıtlarını yazmaları ve sınıf arkadaşları ile paylaşmaları beklenir(20-25 dk).

3. Adım

Bu adımda öğrenciler araştırma sorularına cevap niteliğindeki argümanlarını ortaya koyarlar. Araştırma sorusuna verdikleri cevaplar, gözlemleri ve bulgularından yola çıkarak ortaya koydukları iddiaları, kanıtları ve gerekçelerini içerir. Her grup kendi içinde sorunun cevabını tartışarak ortak noktaya varmaya çalışır. Bu küçük grup tartışmasının ardından, her grubun ortak bir iddia ortaya koymaları ve bu iddiayı uygun veri ve gerekçelerle açıklamaları beklenir. Bu aşamada öğrenciler çalışma yapraklarındaki rapor formatında 3, 4 ve 5. kısımları doldurmaya teşvik edilmelidir(5 dk).

4. Adım

Bir önceki adımın tamamlanmasından sonra her gruba argümanını sınıftaki diğer arkadaşları ile paylaşmak için fırsat verilir. Her grup, araştırma sorunun cevabını(iddia), deney sonucu buldukları ve gözlediklerinin sonunda ortaya koydukları iddianın kanıtlarını ve iddia ile kanıtları bağlayan gerekçelerini tahtaya yazarak/söyleyerek sınıfta paylaşır. Bu adımın asıl amacı öğrencilerin iddia gerekçe ve kanıtlarının sınıftaki diğer arkadaşları ile paylaşmaları diğer bir deyişle her argümanın diğer gruplar tarafından da görülebilir olmasına imkân sağlamaktır(5-10 dk).

Bu basamakta öğretmenin rolü öğrencilere yardımcı olmaktır. Örneğin bir grup iddia ortaya koyup bunu herhangi bir kanıt ile desteklemediğinde, öğretmen öğrencilere sorular sorup onları bir uygun bir açıklama yapmak için yönlendirmelidir. Bir grup yalnızca bir iddiada bulunup bunun için herhangi bir kanıt gösteremiyor ise, öğretmen öğrencilere "Neden böyle düşünüyorsun?", "Bu iddiayı yaptığın deneyden yola çıkarak nasıl kanıtlarsın?" gibi sorular sorarak onları yönlendirmelidir. Bu adım sonunda her grup diğer grubun iddiasını, gerekçesini ve kanıtını görebilir. Başka bir deyişle öğrencilerin diğerlerinin argümanlarını değerlendirmek için fırsat sahibi olurlar ve hangisinin daha uygun olduğuna karar verebilirler.

Gruplar tarafından ortaya konan yanlış veya eksik argümanlara diğer öğrenciler ya da onlar yetersiz ise öğretmen tarafından müdahale edilebilir. Tüm sınıf tartışması sona erdikten sonra öğretmen gerekli gördüğü açıklamaları yapar.

5. Adım

Bu adımda öğretmen öğrencilerden çalışma yapraklarındaki deney raporundaki her bir maddeyi doldurmalarını ister. Bu rapor formatının amacı öğrencilerin araştırmaları sırasında amacı anlamaları ve bilimsel yazma konusunda deneyim kazanmalarıdır. Argümantasyona dayalı sorgulayıcı eğitim modeli deney formatında konu ile ilgili gerekli temel bilgi, araştırma sorusu, kullanılacak deney malzemelerinin listesi ve güvenlik önlemleri yer alır(5-10 dk).

Öğretmen rapor formatının ayrıntılarını öğrenciler için açıklar. Öğrencilerden çalışma yapraklarındaki boş bırakılan yerlere cevaplarını yazmaları istenir. Öğrenciler, deney boyunca takip ettikleri yöntemi, gözlemlerini, deneyden elde ettikleri verileri, iddialarını, kanıtlarını, gerekçelerini yazmaları beklenir. Raporun sonunda değişen fikirler var ise bunların yazılması istenir.

6. Adım

Öğrenciler araştırma raporlarını tamamladıktan sonra, öğretmen her grubun raporunu gelişigüzel diğer gruplara dağıtır. Öğrenciler diğer grupların raporlarını inceler ve grup değerlendirme ölçeğine göre değerlendir. Grup değerlendirme ölçeği, "Grubun iddiası eksik ya da doğru değildir; Grubun sunduğu kanıt eksik ya da doğru değildir; Grubun gerekçesi eksik ya da doğru değildir." şeklinde üç adet değerlendirme ifadesi içerir. Her grup diğer grubun raporunu değerlendirirken bu ifadelerden faydalanarak raporun geçerli ya da geçersiz olduğuna karar verir. Zaman yetersiz ise bu adım bazen atlanabilir(5-10 dk).

7. Adım

Bu adımda her gruba kendi raporlarını geri dönütler ışığında yeniden gözden geçirip düzeltme şansı verilir. Raporun son hali bir sonraki derste getirilmek üzere öğrencilerden istenir. Tamamlanan rapor öğretmene teslim edilir. Zaman yetersiz ise bu adım bazen atlanabilir.

APPENDİX K

SAMPLE ADI LESSON PLAN
DERS PLANI 1

BÖLÜM 1

Dersin adı: Kimya

Sınıfı:

Ünite Adı: Maddenin Halleri

Konu: Gazlar

Önerilen Süre: 90 dk

BÖLÜM 2

İlgili Kazanımlar:

- İdeal gazın davranışlarını açıklamada kullanılan temel varsayımları irdeler(Kinetik Teori).

Ön Bilgiler

- Basınç, sıcaklık, hacim ve mol kavramları daha önce öğrenilmiş olmalıdır.

BÖLÜM 3

Öğretme-Öğrenme Etkinlikleri

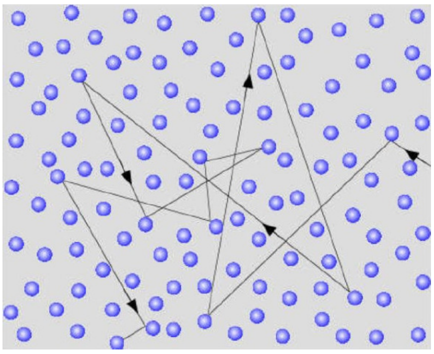
1. ÖĞRENCİLERİN ÖN BİLGİLERİNİN ORTAYA ÇIKARILMASI

Öğretmen öğrencilerin konu ile ön bilgilerini ortaya çıkarmak için günlük hayattan örnekler kullanır. Öncelikle öğrencilere "***Günlük hayatta en sık karşılaştığınız gaz maddeler nelerdir?***" sorusu yöneltilir. Öğrencilerden gelen cevaplarla birlikte "Soluğumuz hava, evde ocakları yakmak için kullandığımız tüp ya da doğal gaz, , LPG gibi çevremizde çokça rastlayabileceğimiz maddeler gaz halindeki maddelerdir." gibi örnekler verilir.

Gaz taneciklerinin davranışlarını açıklamak için geliştirilen teoriye kinetik teori denir.
Bilinen (gerçek) gazların davranışlarına ilişkin uzun süren gözlem ve ölçümler sonucunda bilim adamları gazların davranışlarını anlamayı kolaylaştıran **kinetik teoriyi** geliştirmişlerdir.
Bu teoride öngörülen kabuller aşağıda maddeler halinde verilmektedir.
1. *Kinetik teoriye göre gaz tanecikleri birbiriyle etkileşmeyen, yani aralarında çekme ve itme olaylarının söz konusu olmadığı bağımsız parçacıklar olarak kabul edilir*. Bu yüzden gaz tanecikleri arasındaki uzaklık, taneciklerin kendi büyüklüklerine oranla çok fazladır. Bu olgu havada yol almanın sudakine göre neden daha kolay olduğunu yeterince açıklamaktadır.
2. *Gaz tanecikleri birbirleriyle veya bulundukları kabın çeperleri ile çarpışıncaya kadar her yönde ve çok hızlı doğrusal hareketler yaparlar*. Bu nedenle gaz tanecikleri bulundukları kabın tamamına yayılır ve kabın biçimini alırlar
3. *Gaz taneciklerinin yaptıkları çarpışmalar tümüyle esnek olup, çarpışmada herhangi bir enerji kaybı yoktur*. Böylece çarpışan tanecikler önceki hızları ile başka bir doğrultuda hareketlerini sürdürürler.
4. *Gaz taneciklerinin kinetik enerjileri sıcaklıkla (T) değişir. Gaz ısıtıldığında tanecikler çok daha hızlı hareket ederken, soğutuldukça hızları düşer*. Teorik olarak, belirli bir sıcaklığa inilebildiğinde de tüm hareketler durur. Bu sıcaklık mutlak sıfır olarak bilinir ve -273, 15° C ya da O K (Kelvin) değerindedir.

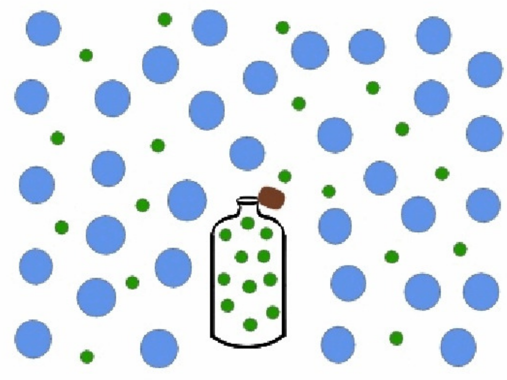
"***Gazlar neden bulundukları kabın hacmini ve biçimini alırlar?***" sorusu ile gazların kinetik teorisine giriş yapılır. Öğrencilerin düşünüp fikir yürütmeleri istenir. Bu noktada konuyu bilmedikleri varsayılarak öğrencilerden tam doğru cevap beklenmemektedir. Tahminde bulunma ve çıkarım yapmaları istenmektedir. Sınıf içi yaklaşık 5 dk'lık soru cevaplarla öğrencilerin ön bilgileri açığa çıkarıldıktan sonra Gazların kinetik teorisi açıklanır.

Gaz Moleküllerinin Hareketleri



Daha sonra gazların yayılması ile ilgili ön bilgilerini belirlemek amacıyla şu soruyu yönlendirilir:

Odanın bir ucunda sıkılan parfüm ya da kolonya kokusunu odanın diğer ucundan alabiliriz. Bu durumun sebebi nedir? ya da ağzı açık bırakılan bir bardaktaki suyun belli bir zaman sonra miktarının azalmasının sebebi nedir?



Öğrenciler günlük hayatta karşılaştıkları bu olayları muhtemelen ön bilgileri ile birleştirip "gazların bulundukları ortama yayılması" şeklinde açıklayacaklardır. Daha sonra öğrencilere kinetik teori ile ilgili etkinlik yapılacağı açıklanır.

2. ETKİNLİĞİN UYGULANMASI- ARGÜMANTASYONA DAYALI SORGULAYICI EĞİTİMİN BASAMAKLARI

1. Adım

Bu adımda öğretmen öğrencilere gazların difüzyonu ile ilgili çalışma yapraklarını dağıtır. Öğrencilerden yaprak üzerinde yer alan bilgiyi ve gazların difüzyonu ile ilgili araştırma sorusunu okumaları istenir. Etkinlikte verilen senaryoya göre Selma ve Metin adlı iki öğrenciden laboratuvarda karışmış olan iki şişeye doğru etiketi yerleştirmeleri istenmektedir. Bu şişelerden birinde NH_3 diğerinde HCl olduğu bilinmektedir. Verilen bu görevi yerine getirmek için öğrenciler bir deney yapmaya karar verirler. Bu noktada, öğrencilerden kendilerini Selma ve Metin'in yerine koyarak bir deney tasarlamaları ve hangi, şişede NH3 hangisinde HCl olduğunu belirlemeleri istenir. Araştırma sorusu "Hangi şişede NH3 hangisinde HCl vardır?" şeklindedir. Bu aşamada öğrencilerden yürütecekleri deney ile ilgili beyin fırtınası yapmaları ve uygun bir metot önermeye çalışmaları beklenir. Etkinlik yaprağındaki araştırma sorusuna cevap vermek için nasıl bir deney düzeneği kuracaklarına grup olarak düşünüp karar vermeleri için yaklaşık 15 dk verilir. Buna alternatif olarak, etkinlik öğrencilere bir önceki dersin sonunda dağıtılıp takip eden derse izleyecekleri yönteme karar verip gelmeleri beklenebilir. Her grup, grup olarak hangi yöntemi izleyeceğine karar verip tahtaya ya da çalışma yapraklarına yazar.

Deneyin Amacı: *Bu deneyde amaç, öğrencilerin iki farklı gazın birbiri içerisinde karıştığını, başka bir ifade ile yayıldığını ve yayılma hızlarını kavrayabilmeleridir.*

Bilgi: *Bu etkinlik gazların birbiri içinde nasıl yayıldığını ispatlamaktadır. Gazların birbiri içerisinde karışması, gaz taneciklerinin gelişi güzel hareket ederken birbirlerine ve kabın çeperlerine çarpmaları ile açıklanır. Bu çarpışmalar sırasında moleküller arası kinetik enerji aktarımı olur. Tek bir taneciğin kinetik enerjisi değişse bile, taneciklerin ortalama kinetik enerjisi değişmez. Bir sistem içerisinde farklı gazlar olsa bile aynı sıcaklıkta bütün gaz moleküllerinin ortalama kinetik enerjisi aynıdır. Aynı sıcaklıkta iki farklı gaz birbiri ile karıştırıldığında moleküllerin ortalama kinetik enerjilerinin eşitliği formülünden faydalanılarak Graham difüzyon yasası çıkarılır.*
Ortalama kinetik enerji sadece sıcaklığa bağlıdır. Aynı kapta bulunan iki gazın ortalama kinetik enerjisi aynı ise;

$E_{K_A} = E_{K_B}$ (A ve B nin kinetik enerjileri eşittir.)

$$\frac{1}{2} \cdot M_A \cdot V_A^2 = \frac{1}{2} M_B \cdot V_B^2$$

$\dfrac{V_A^2}{V_B^2} = \dfrac{M_B}{M_A}$ dan karekök alırsak,

$$\frac{V_A}{V_B} = \sqrt{\frac{M_B}{M_A}}$$

Aynı sıcaklıktaki gazların difüzyon hızları, molekül kütleleri ile ters orantılıdır. Diğer bir deyişle nasıl zayıf olan insanlar daha hızlı koşabilirse, molekül ağırlığı daha az olan gazlarda ağır gazlara göre daha hızlı hareket ederler.

Araştırma Sorusu: *Hangi şişede HCl hangisinde NH_3 var?*

Kullanılacak Malzemeler

- *Derişik HCl*
- *Derişik NH_3*
- *Cam boru*
- *Spor ve lastik*
- *Cetvel*
- *Pamuk*

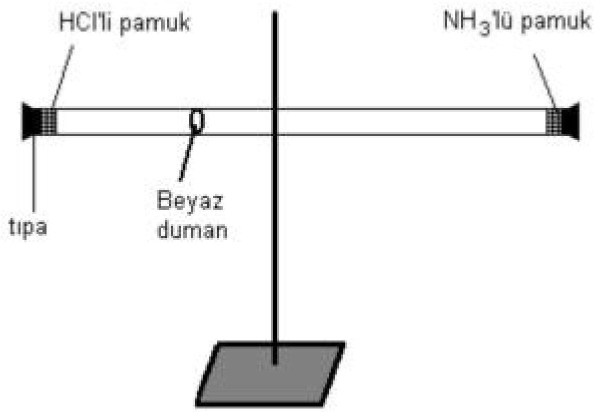
Güvenlik Uyarıları

- Deneyinize başlamadan önce eldiven giyiniz.
- Derişik amonyak ve hidroklorik asit cildinizi tahriş edebilir dikkatli kullanınız.

2. Adım

Bu adımda öğrencilerden izleyecekleri yönteme karar vermiş olmaları ve bunu tahtaya ya da çalışma yapraklarına yazmaları beklenir. İlk olarak öğrenciler herhangi bir eleştiri ya da yönlendirme olmadan izleyecekleri yöntemi yazarlar/bahsederler. Her grup yönteminden bahsettikten sonra kısa bir sınıf tartışması ile grupların yöntemleri sınıf tarafından değerlendirilir. Bu sırada öğretmenin görevi gerekli yönlendirmelerle öğrencilere kılavuzluk etmektir. Gerekli durumlarda öğretmen çalışma yaprağındaki malzeme listesini öğrencilerin bir ipucu olarak kullanmasını sağlamalıdır. Bu sınıf tartışmasına ayrılacak vakit en fazla 15 dk olarak belirlenmiştir. Öğrenci grubunun seviyesi dolayısı önerilen yöntemler üzerinde ile bazı düzeltmeler ve yönlendirmelere gerek duyulabilir. Bu aşamadan sonra öğrenciler yöntemleri ile araştırma sorusunu test etme aşamasına geçerler. Deney sırasında öğrenciler, not tutmaya ve gözlemlerde bulunmaya yönlendirilir.

Bu etkinlikte öğrenciler kimyasalları yalnızca pamuklara şişelerden damlatıp test etmek gibi yetersiz ve uygun olmayan yöntemler önerebilirler. Burada öğretmenin yapması önerilen şey, malzeme listesindeki diğer malzemelerin ne için gerekli olabileceğini öğrencilerin düşünmesini ve deneye katmalarını sağlamaktır. Bu deneyin başında, öğretmen Graham yasasını tahtaya yazar ve çalışma yaprağındaki bilgiyi içeren açıklamalarda bulunur. Öğrencilerden gelen sorular var ise cevaplanır. Yapılan açıklamalar ışığında öğrencilerin iki gazın yayılma hızını karşılaştırırken gazların kütlelerini göz önünde bulundurmaları beklenir. Öğrenciler aşina olmadıkları bir yöntemle karşılaştıklarından laboratuvar araştırmaları sırasında öğretmene sıkça çeşitli sorular yönlendirebilir. Öğretmen bu sorulara doğrudan cevap vermekten kaçınmalı ve "Neden böyle düşünüyorsun?", gibi öğrenciyi düşündürücü ipuçları vermelidir. Grupların uygun olmayan çözümler ürettiği durumlarda öğretmen yönlendirici sorularla öğrencileri araştırmanın farklı yönlerini düşünmeye sevk etmelidir. Örneğin öğrenci grubu beyaz duman formatında gözükecek olan amonyum klorürü (NH_4Cl) göremiyorsa, öğretmen öğrencilere yeni bir deney yapmalarını veya daha fazla kimyasal kullanmalarını önerebilir. Bunların dışında, amonyum klorürün oluşumu zaman alacağından gruplara biraz daha beklemeleri önerilebilir. Bu adımın sonunda öğrencilerin iddialarını ve kanıtlarını yazmaları ve sınıf arkadaşları ile paylaşmaları beklenir(20-25 dk).



Öğrencilerden şekildeki düzeneğe benzer bir düzenek kurmaları beklenir.

Öğrenciler HCl ve NH_3 gazlarının karşılaştıkları noktada beyaz halkanın(NH_4Cl) oluşumunu gözlemlerler. Öğretmen gruplar arası dolaşarak öğrencilere sorular yönlendirir:
"Neden beyaz halka oluştu?",
"Hidroklorik asit ve amonyak pamuklara sıvı olarak damlatıldığı halde nasıl cam borunun ortasında tepkime gerçekleşmiş olabilir?"
"Beyaz halka hangi uca yakın? Neden HCl ye yakın bölgede oluştu?"

Öğrenciler, oluşan beyaz halkanın NH_3 ve HCl uçlarına uzaklıklarını cetvel ile ölçmeleri için yönlendirilebilir.

3. Adım

Bu adımda öğrenciler araştırma sorularına cevap niteliğindeki argümanlarını ortaya koyarlar. Her grup kendi içinde sorunun cevabını tartışarak ortak noktaya varmaya çalışır. Bu küçük grup tartışmasının ardından, her grubun "Birinci şişede HCl vardır" şeklinde ortak bir iddia ortaya koymaları ve bu iddiayı uygun veri ve gerekçelerle açıklamaları beklenir. Bu aşamada öğrenciler çalışma yapraklarındaki rapor formatında 3, 4 ve 5. kısımları doldurmaya teşvik edilmelidir(5 dk).

4. Adım

Bu basamakta öğretmenin rolü öğrencilere yardımcı olmaktır. Örneğin bir grup iddia ortaya koyup bunu herhangi bir kanıt ile desteklemediğinde, öğretmen öğrencilere sorular sorup onları bir uygun bir açıklama yapmak için yönlendirmelidir. Bir grup yalnızca "birinci şişe HCl içerir." iddiasında bulunup bunun için herhangi bir kanıt gösteremiyor ise, öğretmen öğrencilere "Neden böyle düşünüyorsun?", "Bu iddiayı yaptığın deneyden yola çıkarak nasıl kanıtlarsın?" gibi sorular sorarak onları yönlendirmelidir. Bu adım sonunda her grup diğer grubun iddiasını, gerekçesini ve kanıtını görebilir. Başka bir deyişle öğrencilerin diğerlerinin argümanlarını değerlendirmek için fırsat sahibi olurlar ve hangisinin daha uygun olduğuna karar verebilirler.

Öğrencilerden deney ait bulgularını yorumlamaları sırasında iddia ileri sürmeleri ve buna kanıt göstermeleri istenir. Örneğin;

İddia: Birinci şişe HCl içerir.

Kanıt: Oluşan beyaz halka birinci şişeye çok daha yakın mesafede oluşmuştur.(borunun birinci şişeden damlatılan kimyasalın olduğu ucundan 18 cm uzakta).İkinci şişedeki kimyasalın kullanıldığı diğer ucundan ise yaklaşık 32 cm uzakta oluşmuştur. Molekül kütlesi küçük olan NH_3 daha hızlı hareket ederek daha fazla yol almıştır.

Gerekçe: Molekül kütlesi küçük olan tanecikler daha hızlı hareket eder.

Gruplar tarafından ortaya konan yanlış veya eksik argümanlara diğer öğrenciler ya da onlar yetersiz ise öğretmen tarafından müdahale edilebilir.
İddia: Birinci şişe NH_3 içerir.
Kanıt: Çünkü beyaz duman yani NH_4Cl birinci şişeden damlatılan kimyasala daha yakında oluşmuştur.

Şeklinde yanlış bir açıklama var ise;

Çürütme: Amonyak hidroklorik asitten daha hafif olduğu için beyaz dumanın yakın olduğu yer hidroklorik asite daha yakın olmalıdır. Çünkü daha hafif olan molekülü diğerine göre aynı süre içinde daha çok yol almıştır. Birinci şişede HCl vardır.

Birden fazla argümanın yer aldığı bir açıklama ile doğru yanıt verilebilir. Böylelikle öğrenciler diğerlerinin fikirlerini kritik etmeyi öğrenmiş olurlar. Tüm sınıf tartışması sona erdikten sonra öğretmen gerekli gördüğü açıklamaları yapar.

5. Adım

Bu adımda öğretmen öğrencilerden çalışma yapraklarındaki deney raporundaki her bir maddeyi doldurmalarını ister.
Öğretmen rapor formatının ayrıntılarını öğrenciler için açıklar. Öğrencilerden çalışma yapraklarındaki boş bırakılan yerlere cevaplarını yazmaları istenir. Öğrenciler, deney boyunca takip ettikleri yöntemi, gözlemlerini, deneyden elde ettikleri verileri, iddialarını, kanıtlarını, gerekçelerini yazmaları beklenir. Raporun sonunda değişen fikirler var ise bunların yazılması istenir(5-10 dk).

6. Adım:

Öğrenciler araştırma raporlarını tamamladıktan sonra, öğretmen her grubun raporunu gelişigüzel diğer gruplara dağıtır. Öğrenciler diğer grupların raporlarını inceler ve grup değerlendirme ölçeğine göre değerlendir. Grup değerlendirme ölçeği, "Grubun iddiası eksik ya da doğru değildir; Grubun sunduğu kanıt eksik ya da doğru değildir; Grubun gerekçesi eksik ya da doğru değildir." şeklinde üç adet değerlendirme ifadesi içerir. Her grup diğer grubun raporunu değerlendirirken bu ifadelerden faydalanarak raporun geçerli ya da geçersiz olduğuna karar verir. Zaman yetersiz ise bu adım bazen atlanabilir(5-10 dk).

7. Adım

Bu adımda her gruba kendi raporlarını geri dönütler ışığında yeniden gözden geçirip düzeltme şansı verilir. Raporun son hali bir sonraki derste getirilmek üzere öğrencilerden istenir. Tamamlanan rapor öğretmene teslim edilir. Zaman yetersiz ise bu adım bazen atlanabilir.

3. ETKİNLİK SONRASI YAPILACAKLAR

Etkinliğin sonunda öğretmen gerekli gördüğü durumda konuyu özetler.

Bu etkinlik gazların birbiri içinde nasıl yayıldığını ispatlamaktadır. Gazların birbiri içerisinde karışması, gaz taneciklerinin gelişi güzel hareket ederken birbirlerine ve kabın çeperlerine çarpmaları ile açıklanır. Bu çarpışmalar sırasında moleküller arası kinetik enerji aktarımı olur. Tek bir taneciğin kinetik enerjisi değişse bile, taneciklerin ortalama kinetik enerjisi değişmez. Bir sistem içerisinde farklı gazlar olsa bile aynı sıcaklıkta bütün gaz moleküllerinin ortalama kinetik enerjisi aynıdır. Aynı sıcaklıkta iki farklı gaz birbiri ile karıştırıldığında moleküllerin ortalama kinetik enerjilerinin eşitliği formülünden faydalanılarak Graham difüzyon yasası çıkarılır.

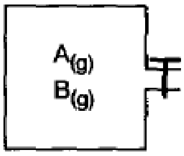
Ortalama kinetik enerji sadece sıcaklığa bağlıdır. Aynı kapta bulunan iki gazın ortalama kinetik enerjisi aynı ise;

$E_{K_A} = E_{K_B}$ (A ve B nin kinetik enerjileri eşittir.)

$$\frac{1}{2} . M_A . V_A^2 = \frac{1}{2} M_B . V_B^2$$

$$\frac{V_A^2}{V_B^2} = \frac{M_B}{M_A}$$ dan karekök alırsak,

$$\frac{V_A}{V_B} = \sqrt{\frac{M_B}{M_A}}$$



A ve B gazları aynı kapta olduğundan yoğunlukları molekül ağırlıklarıyla doğru orantılıdır.

$$\frac{V_A}{V_B} = \sqrt{\frac{M_B}{M_A}} = \sqrt{\frac{d_B}{d_A}}$$

Aynı sıcaklıktaki gazların difüzyon hızları, molekül kütleleri ile ters orantılıdır.

APPENDIX L

BABYSITTER ACTIVITY
Bebek Bakıcısı

Arzu Hanım'ın üç çocuğuna bakacak bir bebek bakıcısına ihtiyacı var. Arzu hanımın, 9 yaşında bir erkek, 6 yaşında bir kız, ve üç yaşında bir erkek çocuğu vardır. Arzu Hanım cumartesi günü sabah 11' den gece yarısına kadar çalışacaktır. Bakıcı öğle yemeği ve akşam yemeğini hazırlamalı, çocuklara gün boyunca bakmalı ve gece uyutmalıdır. Arzu Hanım'ın aşağıdaki 4 gençten birini bu iş için seçmesi gerekmektedir. Hangisini seçsin?

Her seçeneği tartışın. Her grup bir bebek bakıcısı seçerek, diğer gruplara neden o kişiyi seçtiklerini açıklamalı.

Sevgi …. Ailenin 4üncü ve en küçük çocuğu. Evde birçok kız ve erkek kardeşi var. Çocuklarla güzel oyunlar oynayabilir. Yemek yapmayı sevmez. Uyuma zamanı ve diğer kurallarda da çok sıkıdır.

Anıl …. spor yapmayı ve erkek çocuklarıyla oynamayı sever. Arkadaş canlısı ve anlayışlıdır, çocuklarla hiç kavga etmez. TV seyretmeyi çok sever. Annesi eve döndüğünde onun yüzünden evi hep dağınık bulur.

Suna …. Kardeşlerinin en büyüğü. Telefonda konuşmayı çok sevdiği bir erkek arkadaşı var. Çok iyi yemek yapar ama mutfağı dağınık bırakır. Çocukları oyun oynamaları için serbest bırakır, onlarla oynamayı ya da onlara kitap okumayı sevmez. İlk yardım eğitimi almıştır. Daha önce Arzu Hanım için bebek bakıcılığı yapmıştır ve eğer gerekirse yatılı olarak kalabilir.

Fırat …. Evde tek çocuktur. Okulda çok başarılıdır. Okumayı çok sever ve kitaplarını hep yanında taşır. Eğer istenirse çocuklara kitap okuyabilir. Yemek yapmayı bilmez fakat deneyebilir. Çok kibardır fakat konuşmayı pek sevmez. Arzu Hanımla aynı mahallede oturuyor ve her hangi bir problem durumunda ailesini arayabilir.

APPENDIX M

ADI ACTIVITY SHEET
ÇALIŞMA YAPRAĞI-1

Grubun Adı:

Hangi şişede HCl hangisinde NH_3 var?

Selma ve Metin, Kimya Laboratuvarında öğretmenlerinin verdiği deneyi yapmak üzere derişik HCl ve NH_3 çözeltilerini damlalıklı şişelere koyup etiketlemek üzere görevlendirilirler. Çözeltileri şişelere koyup etiketleme kısmına geldiklerinde hangi şişede hangi çözelti olduğunu karıştırırlar. Şişelerdeki çözeltileri bulmak için bir deney tasarlamaya karar verirler.
Selma ve Metin bu deneyi tasarlarken şu bilgiden faydalanırlar. "**HCl ve NH_3 gazları tam karşılaştıkları zaman oluşan NH_4Cl beyaz bir halka şeklinde gözlemlenebilmektedir.**"
Kendinizi Selma ve Metin'in yerine koyarak tasarladığınız deney sonucuna göre şişelerin etiketlerini yerleştirin.

Bilgi: Bu etkinlik gazların birbiri içinde nasıl yayıldığını ispatlamaktadır. Gazların birbiri içerisinde karışması, gaz taneciklerinin gelişi güzel hareket ederken birbirlerine ve kabın çeperlerine çarpmaları ile açıklanır. Bu çarpışmalar sırasında moleküller arası kinetik enerji aktarımı olur. Tek bir taneciğin kinetik enerjisi değişse bile, taneciklerin ortalama kinetik enerjisi değişmez. Bir sistem içerisinde farklı gazlar olsa bile aynı sıcaklıkta bütün gaz moleküllerinin ortalama kinetik enerjisi aynıdır. Aynı sıcaklıkta iki farklı gaz birbiri ile karıştırıldığında moleküllerin ortalama kinetik enerjilerinin eşitliği formülünden faydalanılarak Graham difüzyon yasası çıkarılır.

Ortalama kinetik enerji sadece sıcaklığa bağlıdır. Aynı kapta bulunan iki gazın ortalama kinetik enerjisi aynı ise;

$E_{K_A} = E_{K_B}$ (A ve B nin kinetik enerjileri eşittir.)

$$\frac{1}{2} . M_A . V_A^2 = \frac{1}{2} M_B . V_B^2$$

$\frac{V_A^2}{V_B^2} = \frac{M_B}{M_A}$ dan karekök alırsak,

$$\frac{V_A}{V_B} = \sqrt{\frac{M_B}{M_A}}$$

Aynı sıcaklıktaki gazların difüzyon hızları, molekül kütleleri ile ters orantılıdır. Diğer bir deyişle nasıl zayıf olan insanlar daha hızlı koşabilirse, molekül ağırlığı daha az olan gazlarda ağır gazlara göre daha hızlı hareket ederler.

Araştırma Sorusu: Hangi şişede HCl hangisinde NH_3 var?

Kullanılacak Malzemeler

- Derişik HCl
- Derişik NH_3
- Cam boru
- Spor ve lastik
- Cetvel
- Pamuk

Güvenlik Uyarıları

- Deneyinize başlamadan önce eldiven giyiniz.
- Derişik amonyak ve hidroklorik asit cildinizi tahriş edebilir dikkatli kullanınız.

1-Deney Tasarlama: Araştırma sorusuna cevap bulmak için nasıl bir yol izledim?
2-Gözlemler ve bulgular: Yaptıklarım sonucunda neler buldum?(Gözlemlerim, bulduklarım neler?)
3-İddialar: Gözlemlerim bulgularım sonucu ne **iddia** ediyorum?(Deney sonunda ulaştığım genel fikir, Örneğin; X...maddesi asittir.)
4-Deliller/Kanıtlar: Bulduklarım ve gözlediklerim sonunda yukarıdaki iddiayı ortaya koydum çünkü **delillerim** şunlar;(Deney sonucu bulduklarım. Örneğin;X... maddesi asittir. Çünkü, deney sonucunda pH:4 buldum......)
5-Gerekçeler/Nedenler: İddiamı desteklerken şu delileri kullandım çünkü **gerekçelerim** şunlar;(Örneğin, Çünkü asitlerin pH'ı 0-6 arasındadır. pH:4 olması gösterir ki madde asidik özellik göstermektedir.)

6-Değişen Fikirler:

Düşüncelerimi başkaları ile karşılaştırdım ve düşüncelerim şu yönde değişti;
(Yani düşüncelerimi arkadaşlarımın düşünceleri ile karşılaştırdım ve değişen fikirlerim şunlar.....)

APPENDIX N

PEER REVIEW SHEET

Grup Değerlendirme Ölçeği

Değerlendiren Grup:
Değerlendirdikleri Grup:
Geçerli/Geçersiz:

Grubun raporundaki iddiası, kanıtı ve gerekçesini ayrı ayrı değerlendirip size uygun gelen seçeneği işaretleyiniz. Seçtiğiniz yanıtın nedenini boş bırakılan kısımda açıklayınız.

- Grubun iddiası doğrudur.(3)
- Grubun iddiası eksiktir.(2)
- Grubun iddiası doğru değildir. (1)
- Çünkü;

- Grubun sunduğu kanıt doğrudur.(3)
- Grubun sunduğu kanıt eksiktir.(2)
- Grubun sunduğu kanıt doğru değildir. (1)
- Çünkü;

- Grubun gerekçesi doğrudur.(3)
- Grubun gerekçesi eksiktir.(2)
- Grubun gerekçesi doğru değildir. (1)
- Çünkü;

APPENDIX O

SAMPLE STUDENT ADI LABORATORY REPORT-1

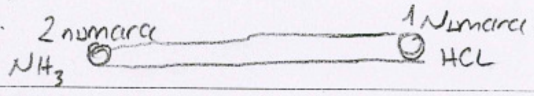
ÇALIŞMA YAPRAĞI-1

Grubun Adı: GRUP HNO_3
10-D

Hangi şişede HCl hangisinde NH_3 var?

1-Deney Tasarlama:
Araştırma sorusuna cevap bulmak için nasıl bir yol izledim?

Önce pamukları 1 ve 2 numaralı solüsyon ile ısladık. Ardından cam borunun iki ucuna tıpa ile yerleştirdik. Hava boşluklarını tıpa ile kapattık sonra beyaz halkanın oluşması için beklemeye başladık.



2-Gözlemler ve bulgular:
Yaptıklarım sonucunda neler buldum?(Gözlemlerim, bulduklarım neler?)

Amonyağın HCL'ya göre daha hızlı yayıldığını gözlemledik. Biz 1 ve 2 numaralı gazların neler olduğunu gazların aldıkları yola bakarak bulduk.

3-İddialar:
Gözlemlerim bulgularım sonucu ne **iddia** ediyorum?(Deney sonunda ulaştığım genel fikir. Örneğin: X...maddesi asittir.)

Grup olarak iddia ediyoruz ki, NH_3 ~~gazı~~ gazı HCL'dan hızlı yayılır.

4-Deliller/Kanıtlar:
Bulduklarım ve gözlediklerim sonunda yukarıdaki iddiayı ortaya koydum çünkü **delillerim** şunlar:(Deney sonucu bulduklarım. Örneğin;X... maddesi asittir. Çünkü, deney sonucunda pH:4 buldum......)

Çünkü gazların yayılma hızları oranı ağırlıklarının kareköküyle ters orantılı bağıntısından NH_3 hafif ve hızlıdır.

5-Gerekçeler/Nedenler: İddiamı desteklerken şu delileri kullandım çünkü **gerekçelerim** şunlar;(Örneğin, Çünkü asitlerin pH'ı 0-6 arasındadır. pH:4 olması gösterir ki madde asidik özellik göstermektedir.) Çünkü boruda NH_3 koyduğumuz taraf diğer uca daha çok yaklaşmışken, HCL daha az yol gittiğinden daha kendi tarafındaydı.
6-Değişen Fikirler: Düşüncelerimi başkaları ile karşılaştırdım ve düşüncelerim şu yönde değişti: (Yani düşüncelerimi arkadaşlarımın düşünceleri ile karşılaştırdım ve değişen fikirlerim şunlar.....) Değişmedi. Deney tahminlerimiz doğrultusunda sonuçlandı. Okuduklarımız ve yaptığımız deney aynı şeyi söylüyordu.

SAMPLE STUDENT ADI LABORATORY REPORT-2

ÇALIŞMA YAPRAĞI-1

Grubun Adı: Parlayan yıldızlar Takımı

Hangi şişede HCl hangisinde NH_3 var?

1-Deney Tasarlama:
Araştırma sorusuna cevap bulmak için nasıl bir yol izledim?

Molekül ağırlıkları farklı olan iki gazı bir borunun uçlarına koyup gözlemledik.

$(m_{NH_3} = 12g \,/\, m_{HCl} = 36{,}5gr)$

2-Gözlemler ve bulgular:
Yaptıklarım sonucunda neler buldum?(Gözlemlerim, bulduklarım neler?)

Gazların karşılaştığı yerde beyaz bir bulut oluştu.
Bu bulut NH_3 olan ikinci şişeye daha yakındı.

3-İddialar:
Gözlemlerim bulgularım sonucu ne **iddia** ediyorum?(Deney sonunda ulaştığım genel fikir. Örneğin: X...maddesi asittir.)

NH_3 molekülü daha hızlıdır.

4-Deliller/Kanıtlar:
Bulduklarım ve gözlediklerim sonunda yukarıdaki iddiayı ortaya koydum çünkü **delillerim** şunlar:(Deney sonucu bulduklarım. Örneğin;X... maddesi asittir. Çünkü, deney sonucunda pH:4 buldum......)

NH_3'ün ilerlediği mesafe yaklaşık 35cm.
HCl'nin " " " 15 cm

5-Gerekçeler/Nedenler:
İddiamı desteklerken şu delileri kullandım çünkü **gerekçelerim** şunlar;(Örneğin, Çünkü asitlerin pH'ı 0-6 arasındadır. pH:4 olması gösterir ki madde asidik özellik göstermektedir.)

$m_{NH_3} = 17 gr$ $m_{HCl} = 36{,}5 gr$

NH_3 daha hızlıdır çünkü molekül kütlesi daha küçüktür.

6-Değişen Fikirler:
Düşüncelerimi başkaları ile karşılaştırdım ve düşüncelerim şu yönde değişti;
(Yani düşüncelerimi arkadaşlarımın düşünceleri ile karşılaştırdım ve değişen fikirlerim şunlar.....)

Değişmedi.

APPENDIX P

PERMISSION OF STUDY

ÖĞRENCİ İŞLERİ
DAİRESİ BAŞK...

T.C.
ANKARA VALİLİĞİ
Milli Eğitim Müdürlüğü

Sayı : 14588481/605.99/305022 25/03/2013
Konu: Araştırma izni

ORTA DOĞU TEKNİK ÜNİVERSİTESİNE
(Öğrenci İşleri Daire Başkanlığı)

İlgi: a) MEB Yenilik ve Eğitim Teknolojileri Genel Müdürlüğünün 2012/13 nolu Genelgesi.
b) 12/03/2013 tarih ve 2909 sayılı yazınız.

Üniversiteniz Eğitim Fakültesi Doktora Öğrencisi Nilgün DEMİRCİ' nin **"Bilimsel tartışma yönteminin 10. sınıf öğrencilerinin gazlar konusunu anlamalarına etkisi"** konulu tezi kapsamında çalışma yapma talebi Müdürlüğümüzce uygun görülmüş ve araştırmanın yapılacağı İlçe Milli Eğitim Müdürlüğüne bilgi verilmiştir.

Uygulama örneklerinin (33 sayfa) araştırmacı tarafından uygulama yapılacak sayıda çoğaltılması ve çalışmanın bitiminde iki örneğinin (cd ortamında) Müdürlüğümüz Strateji Geliştirme Bölümüne gönderilmesini arz ederim.

İlhan KOÇ
Müdür a.
Şube Müdürü

...venli Elektronik İmzalı
Aslı ile Aynıdır.
26/3/2013

Yaşar SUBAŞI

29-03-2013-5563

Bu belge, 5070 sayılı Elektronik İmza Kanununun 5 inci maddesi gereğince güvenli elektronik imza ile imzalanmıştır
Evrak teyidi http://evraksorgu.meb.gov.tr adresinden 3807-056f-32f2-90d7-f991 kodu ile yapılabilir.

Konya yolu Başkent Öğretmen Evi arkası Beşevler ANKARA
e-posta: istatistik06@meb.gov.tr
Ayrıntılı bilgi için: Nermin ÇELENK
Tel: (0 312) 221 02 17/134-135

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name : Demirci Celep, Nilgün

Nationality : Turkish (TC)

Date/Place of Birth : 15 September 1983 / Ankara

E-mail : demirci.nilgun@gmail.com

EDUCATION

Degree	Institution	Year of Graduation
MS	Gazi University, Department of Secondary Science and Mathematics Education, Chemistry Education	2008
BS	Gazi University, Department of Secondary Science and Mathematics Education, Chemistry Education	2006
High School	Batıkent Süper Lisesi / Ankara	2001

WORK EXPERIENCE

Year	Place	Enrollment
2008-2014	METU, Department of Secondary Science and Mathematics Education	Research Assistant
2007-2008	Gazi University, Department of Secondary Science and Mathematics Education, Chemistry Education	Instructor (paid)
2000-2001	Gazi Çiftliği Lisesi	Internship

PUBLICATIONS

Master Thesis

- **Demirci, N.,** (2008), Toulmin'in Bilimsel Tartışma Modeli Odaklı Eğitimin Kimya Öğretmen Adaylarının Temel Kimya Konularını Anlamaları ve Tartışma Seviyeleri Üzerine Etkisi, Published Master Thesis, Gazi Üniversitesi, Yüksek Lisans Tezi, Ankara.

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- **Demirci, N.**, Yıldıran, D. & Geban, Ö. (2012). *Kimya Öğretmen Adaylarının Kimyasal Denge Konusundaki Kavramları ve Kavram Yanılgılarının İncelenmesi.* X. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, Niğde.
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