EFFECT OF CASE BASED LEARNING INSTRUCTION ON 11TH GRADE STUDENTS' UNDERSTANDING OF ACIDS AND BASES CONCEPTS AND THEIR MOTIVATION TO LEARN CHEMISTRY

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EFFECT OF CASE BASED LEARNING INSTRUCTION ON 11TH GRADE STUDENTS' UNDERSTANDING OF ACIDS AND BASES CONCEPTS AND THEIR MOTIVATION TO LEARN CHEMISTRY

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ABSTRACT

THE EFFECT OF CASE BASED LEARNING INSTRUCTION ON 11TH GRADE STUDENTS' UNDERSTANDING OF ACIDS AND BASES CONCEPTS AND THEIR MOTIVATION TO LEARN CHEMISTRY

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In the last semi centennial, researches showed that constructivist learning methods are the most effective when it comes to students' conceptual understanding and motivation, because of their activation of students' prior knowledge that leads to meaningful learning. Thus, in this dissertation, the main purpose is to explore the effects of case-based learning, which is a type of constructivist learning method, on students' understanding of acids and bases concepts and their motivation to learn chemistry when compared to traditionally designed teaching method on 11th grade students.

292 eleventh grade students from a total of eight classes of a chemistry course from two different school types in two different cities of Turkey in 2013-2014 spring semesters were enrolled in the study. The classes were randomly assigned as experimental and control group. Experimental group students were instructed by case-based learning method in which specific situations from real life were discussed whereas control group students were instructed by traditional method.

The data were collected by the adapted version of Science Motivation Questionnaire (SMQ) that was restricted to chemistry and translated into Turkish by

Çetin-Dindar and Geban (2010) and Acids and Bases Test (ABT) developed by the researcher. At the beginning of the implementation, in order to evaluate students' prior knowledge and their motivation to learn chemistry the instruments ABT and CMQ were administered as pre-tests to both control and experimental groups. Throughout the eight weeks during the implementation, case based learning (CBL) instruction was used in the experimental group and the traditionally designed instruction was used in the control group. After the implementation, the instruments CMQ and ABT were again administered to both groups as post-tests to evaluate students' understanding on acids and bases concepts and their motivation to learn chemistry. Afterwards, the collected data were analyzed descriptively and inferentially.

The results of the study showed that case based learning instruction results in higher understanding of acids and bases concepts than the traditionally designed instruction method. Also, there was a significant difference between both groups in the favor of experimental group with respect to students' motivation to learn chemistry. Moreover, the result of this study also proved students to have misconceptions related to acids and bases concepts and some new misconceptions were also introduced to the literature. Furthermore, case base learning (CBL) instruction was found to be effective on overcoming these misconceptions when compared to traditionally designed instruction method.

Keywords: case based learning, misconceptions, motivation to learn chemistry, acids and bases

ÖZ

ÖRNEK OLAY TABANLI ÖĞRENME YÖNTEMİNİN 11. SINIF ÖĞRENCİLERİNİN ASİTLER VE BAZLAR KONUSUNDAKİ KAVRAMSAL ANLAMALARINA VE KİMYA DERSİNİ ÖĞRENMEYE YÖNELİK MOTİVASYONLARI ÜZERİNE ETKİSİ

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Son elli yıllık dönemde yapılan çalışmalar, yapılandırıcı yaklaşıma dayalı öğretim yöntemlerinin, öğrencilerin ön bilgilerini aktive ederek anlamlı öğrenmeyi desteklemeleri sebebiyle, kavramsal anlama ve öğrenci motivasyonları açısından en etkili yöntemler olduğunu göstermiştir. Bu sebeple, bu tezin ana amacı, 11. sınıf öğrencilerinin asitler ve bazlar konusundaki kavramsal anlamalarına ve kimya dersini öğrenmeye yönelik öğrenci motivasyonlarına geleneksel öğretim yöntemine kıyasla yapılandırıcı yaklaşıma dayalı bir öğretim yöntemi olan örnek olay tabanlı öğrenme yönteminin anlamlı bir etkisinin olup olmadığını incelemektir.

Bu çalışma, 2013-2014 öğretim yılının ilkbahar döneminde, Ankara'da yer alan bir Anadolu lisesi ile Karabük'de yer alan bir fen lisesi olmak üzere iki farklı okulda okuyan, sekiz farklı sınıftan toplam 292 onbirinci sınıf öğrencisi ile gerçekleştirilmiştir. Çalışmada deney ve kontrol grubu olmak üzere iki farklı grup kullanılmış; sınıfların kontrol ve deney grubu olarak seçimleri ise rastgele yapılmıştır. Deney grubunda yer alan öğrenciler, günlük hayattan alınmış belirli durumların tartışıldığı örnek olay tabanlı öğrenme yöntemi ile öğrenim görürlerken kontrol grubu öğrencileri ise geleneksel öğretim yöntemi ile öğrenim görmüşlerdir.

Çalışmanın verileri, Çetin-Dindar ve Geban (2010) tarafından fen motivaston anketinin (SMQ) Türkçeye uyarlanan ve kimya ile sınırlandırılarak oluşturulan kimya motivasyon anketi (CMQ) ile; araştırmacının kendisi tarafından geliştirilen Asit Baz Testi (ABT) yardımıyla toplanmıştır. Uygulamanın başında öğrencilerin asitler ve bazlar konusundaki ön bilgilerini ve kimya öğrenmeye yönelik motivasyonlarını tespit etmek amacıyla her iki gruba CMQ ve ABT ölçme araçları ön-test şeklinde uygulanmıştır. Sekiz hafta süren uygulama sürecinde, deney grubundaki öğrenciler örnek olay tabanlı öğrenme yöntemi ile; kontrol grubundaki öğrenciler ise geleneksel öğretim yöntemi ile öğrenim görmüşlerdir. Uygulamanın sonunda, öğrencilerin asitler ve bazlar konusundaki bilgilerini ve kimya öğrenmeye yönelik motivasyonlarını tespit etmek amacıyla her iki gruba CMQ ve ABT ölçme araçları bu kez son-test şeklinde uygulanmıştır.

Uygulama sürecinde toplanan veriler tanımlayıcı ve çıkarımsal analizler ile incelenmişlerdir. Çalışmanın sonuçları, örnek olay tabanlı öğrenme yönteminin geleneksel öğretim yöntemine göre asitler ve bazlar konusunun öğrenilmesi açısından daha başarılı olduğunu göstermiştir. Bu bulgunun yanı sıra, her iki grup arasında kimya motivasyonu açısından, deney grubunu destekleyen yönde anlamlı bir fark bulunmuştur. Ayrıca, yapılan çalışmanın sonuçları ayrıca öğrencilerin genelinde asitler ve bazlar konusunda kavram yanılgıları olduğu tespit edilmiştir ve yeni kavram yanılgıları ortaya çıkartılmıştır. Tüm bu sonuçlara ek olarak, örnek olay tabanlı öğrenme yönteminin öğrencilerin sahip oldukları bu kavram yanılgılarını gidermekte etkili olduğu sonucuna ulaşılmıştır.

Anahtar Kelimeler: örnek olay tabanlı öğrenme, kavram yanılgıları, kimyaya yönelik motivasyon, asitler ve bazlar

To my dearest husband and family

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TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

LIST OF ABBREVIATIONS

EG : Experimental Group

CG : Control Group

S.D. : Standart Deviation

S.E. : Standard Error

H.S.: High School

Anatolian High School: AHS

Science High School: SHS

GRP : Group

SCH : School

Min. : Minimum

Max.: Maximum

TDIM : Traditionally Designed Instruction Method

CBL : Case Based Learning

ABT : Acids and Bases Test

Pre-ABT : Pre-Test Scores of Acids and Bases Test

Post-ABT : Post-Test Scores of Acids and Bases Test

SMQ : Science Motivation Questionaire

CMQ : Chemistry Motivation Questionaire

SE : Self-Efficacy in Learning Chemistry

ANX : Anxiety about Chemistry Assessment

GO : Relevance of Learning Chemistry to Personal Goals

IM : Intrinsically Motivated Chemistry Learning

SD : Self-Determination for Learning Chemistry

Pre-CMQ : Pre-Test Scores of Chemistry Motivation Questionaire

Post-CMQ : Post-Test Scores of Chemistry Motivation Questionaire

Pre-SE : Pre-Test Scores of Self-Efficacy in Learning Chemistry

Post-SE : Post-Test Scores of Self-Efficacy in Learning Chemistry

Pre-ANX : Pre-Test Scores of Anxiety about Chemistry Assessment

Post-ANX : Post-Test Scores of Anxiety about Chemistry Assessment

Pre-GO : Pre-Test Scores of Relevance of Learning Chemistry to Personal Goals

Post-GO : Post-Test Scores of Relevance of Learning Chemistry to Personal Goals

Pre-IM : Pre-Test Scores of Intrinsically Motivated Chemistry Learning

Post-IM : Post-Test Scores of Intrinsically Motivated Chemistry Learning

Pre-SD : Pre-Test Scores of Self-Determination for Learning Chemistry

Post-SD : Post-Test Scores of Self-Determination for Learning Chemistry

DVs : Dependent Variables

IVs : Independent Variables

CHAPTER 1

INTRODUCTION

As the importance of education for human life was understood; researchers have been trying to define the best teaching strategies for better learning (Borich, 2004; Dunne & Wragg, 1994**;** Killen, 1996). For this reason, many learning theories had been developed. At the end of 19th century, the world accepted behaviorist theory as the most powerful teaching strategy which left its place to cognitivist theories of learning as early as the 1920, after the realization of the limitations in explaining the social behaviors in the behaviorist approach to understand learning. This realization led the cognitive revolution began with Bandura's Social Cognitive Theory (Dembo, 1994). During 1960's cognitivist approaches to teaching became evident in psychology and education (Saettler, 2005) with the theories developed by Bruner (1966), Piaget (1968) and Vygotsky (1978). Since Piaget's theory accepts children plays are the necessary part of cognitive development (Wadsworth, 1996) and since Vygotsky's theory accepts social interaction as a core point for cognitive improvement of an individual (Driscoll, 2005), the view to teaching and learning began to change again and the new teaching approach included both social interaction and the process of students' building up their own learning which is called as the constructivism. Nowadays, constructivism is accepted as the most applied theory of learning and teaching that leads students to success (Capriariis, Barman, & Magee, 2001; Jungst, Licklider, & Wiersema, 2003; Sigler & Saam, 2007).

Constructivism is simply based on the idea that the learners control their own learning processes so that they also construct their own knowledge (Hein, 1991). Constructivist learning theory indicates that learning could occur by constructing students' own knowledge (Herron & Nurrenbern, 1999). It is also accepted constructivist learning theories to provide high achievers since it is suggested that achievement gains are most likely to occur in classes that optimally combine warm and supportive relationships, an emphasis on specific academic tasks and accomplishments and a clear, orderly and well-structured learning environment (Moos, 1979). Thus, it can be concluded that constructivism has a positive influence on students' understanding, learning and achievement.

The main characteristic of constructivist learning environment is that a specific problem drives learning, rather than acting as an example of the concepts of the subject matter (Papanikolaou & Grigoriadou, 2009). In a well-structured learning environment design, the students should be engaged in complex thinking exercises which will require application of higher order thinking skills. In other words, the problems introduced should require a detailed examination and reasoning. Each student should have a chance to construct their own ideas about the problem in order to give meaning to the solution of the problem given. For this reason, the given problem should include real-life applications that are interesting, relevant, and meaningful for the students.

There are different types of constructivist models that have been applied to teaching. These are problem-based learning, learning cycle models, argumentation, demonstration, etc. One other is called as the case based learning.

Case based learning (CBL) has been used in many areas of education such as law, medicine, clinical health, business and science as an alternative to the traditionally designed lectures as instructional method (Garvey, O'Sullivan & Blake, 2000). It could simply be put under constructivist approach of teaching since it is a learner centered strategy that focuses on students' building their own knowledge so that students' higher order (Herreid, 1994; Tarkın, 2014) and critical thinking skills (Alvarez, 1990; Uluyol & Güyer, 2014; Yoo & Park, 2014), next to their problem solving skills, decision making abilities and their self-evaluation are promoted with CBL (Amos & White, 1998; Dowd & Davidhizar, 1999; Harman, et al., 2015; Rybarczyk, et al., 2007) . It also includes intense interaction between the students that will then increase students' communication skills (Dupuis & Persky, 2008). In addition, cases were found to impact students' learning, content knowledge and their participation in a positive way (Pai, 2009; Yadav, et al., 2008).

CBL engages students in discussion of daily life examples that are introduced as cases (Merseth, 1991; Spiro & Jehng, 1990; Yalçınkaya et al., 2012). So, it is important to note that the cases applied during CBL instruction should be well-structured examples which were reflecting the real-life situations. In addition to these, the purpose of the given cases should be providing students sufficient experience that could be used in their daily life later, highlighting an issue the teacher wants to bring to the attention of the students so that provide an opportunity for the students to show their understanding by responding to the situation given in the case (Jarz, Kainz, & Walpoth, 1997; Merseth, 1991). According to Smith and Ragan (2005), learners that are given a realistic situation, make a connection between the given story and their own lives and they respond as one of the characters of the story who must solve the problem. In the CBL instruction design, students are working collaboratively in small groups to examine the case. The case is then discussed in class highly directed by the teacher.

Cases used in CBL instruction provide a meaningful source for learning, with an unforgettable anchoring experience on which the students might construct new understandings. By the help of the daily-life related cases in CBL instruction, students' interest to the related concept should increase and they should find a chance to gain experience on how to solve real life problems they might come face to face with. CBLs could also help learners improve their critical thinking skills (Alvarez, 1990; Uluyol & Güyer, 2014; Yoo & Park, 2014) while assessing the information provided and identifying false assumptions in a case (Savery, 2006). Moreover, CBL has many advantages for learning since it promotes student accountability while developing active, communicating, discussing environment in which the students are working in groups cooperatively and where they were receiving feedback from each other and from their teachers.

In addition to these positive effects, CBL also increases students' motivation (Angeli, 2004; Çam & Geban, 2013; Herreid, 1994; Sutyak, Lebeau, & O'Donnell, 1998; Yalçınkaya, 2010; Yalçınkaya et al., 2012) which is because of students' feeling involved when they are a part of the real problem. Since, CBL applies daily-life problems as constructivist approach suggests for meaningful learning, it can be concluded that as the daily-life problems are introduced to students by CBL instruction, it also enhances students' learning by not only taking students' attention, but also increasing students' motivation. For this reason, another advantage of CBL is accepted to be its positive effect on students' motivation. Motivation is an essential affective variable that is needed for learning to occur (Hargrove, 1969; Hsieh, 2014; Kan &Akbaş, 2006; Schweinle, Meyer, & Turner, 2006; Tollefson, 2000) which could be defined as "a process for goal-directed activity that is instigated and sustained" (Pintrich & Shunk, 2002, p.5). When students become motivated, their interest in learning the related concepts also increases. Then, students become more willingly to understand the related topics to solve the given daily-life problem. In other words, once the students become motivated, the result will be learning and learning should be evaluated from the students' achievement (Bruinsma, 2004; Weiner, 1969). There are several researches that proved the effect of CBL on students' motivation that promotes learning and consequently students' achievement (House, 1993; Oliver & Simpson, 1988; Weiner, 1970).

As the positive effects of motivation on students' achievement was proved and the effect of CBL on students' understanding that results in improved achievement has been revealed, in the recent years science education highly shifted to constructivist teaching methods (Conner, 2013; Martin, 2003) because of students' problems in learning or understanding science topics has not been remedied yet (Akkuş, Kadayıfçı, Atasoy, & Geban, 2003; Driver & Oldham, 1986). Several researches indicated that students mainly have difficulty in understanding theoretical scientific concepts in different areas that results students' achievement in science to be low (see Driver, et al., 1995; Garnett, Garnett, & Hackling, 1995; Pozo, Gómez, & Sanz, 1999; Stavy 1995). One of the most problematic science areas is chemistry (Albanese & Vincentini, 1997; Boo, 1998; Chiu, et al., 2013; Griffiths & Preston, 1992; Stavy, 1995; Valanides, 2000). Chemistry includes many topics that influence daily-life. Even if chemistry is all around, the students have difficulty to integrate what they learn with the nature (Saul & Kikas, 2003). In order to be good at chemistry, it is important for a student to make connections with their real-life environment since chemistry is everywhere. For this reason, in order to ease chemistry learning, real-life problems should be applied. By the help of real life problems, students' motivation, interest and attitudes to learn chemistry topics may also increase that consequently increase students' understanding of the related concepts which in turn increase students' achievement. In addition to this, if students are provided more student-centered environments in which they could interact with each other, make discussions or construct their own reasoning to explain the given chemistry concepts; their social skills, self-confidence, high order thinking skills and collaboratively working abilities should also be enhanced.

Moreover, as mentioned above, CBL instruction was found to be effective on students' understanding was proved so that it is also integrated to chemistry teaching in order to increase students' understanding which in turn increases students' academic achievement. When several topics of chemistry have been studied, literature revealed students to have learning and understanding difficulties mainly in acid-base topic of chemistry since traditionally designed instruction method for teaching acid-base topic is not enough. Students generally have problems in understanding the reactions under the topic of acids and bases. To give an example, Schmidt (2000) emphasized, because of the oxygen in the oxide and hydroxide, the students to believe the reaction occurred between hydrochloric acid and magnesium oxide/hydroxide to be a redox reaction. In addition to learning difficulties, the studies showed that students have many misconceptions or while learning acid-base chapter. These misconceptions are preventing students' learning because of not being able to make meaningful linkages between the new conceptions and their own conceptions. According to Nakhleh (1992), one of the reasons of these misconceptions might be students coming to the lectures by holding a different meaning for everyday words in students' minds that had a different scientific meaning or because of students not visualizing the chemical reactions as dynamic interactions spontaneously. Other reasons for these misconceptions to occur might be because of students' personal experiences, their interactions with classmates, the culture they live in and the language, their own teachers, media, the textbooks they work on or their lack of understanding from the previous courses (Fellows, 1994; Hewson & Hewson, 1983; Nakhleh, 1992).

Since it was not easy to overcome students' misconceptions (DiSessa, 1982), several constructivist teaching strategies like learning cycle models (Çetin-Dindar, 2010) or CBL (Çam, 2009; Yalçınkaya, 2010) have been suggested for preventing students from misconceptions in the last century (Lee & Fraser, 2000; Yager, 1995). The reason for applying constructivist teaching strategies was because of their application to students' prior knowledge in order to make the logical connection with the new knowledge by the help of constructivist teachers so that students were prevented from forming misconceptions. Another reason for applying constructivist teaching strategies was to increase learning on acid-base topic of chemistry. For example; Hilbing and Barke (2000) applied visual and thinking models (as cited in Morgil & Gungor, 2007). Meyer, Schmidt, Nozawa and Panee (2003) applied demonstrations and experiments while teaching acids and bases. These studies proved that learning by doing improves students' performance instead of theoretical learning as constructivism emphasis.

Even if different teaching methods related to constructivism have been applied to acid-base topic of chemistry, none of them connected the real-life with the acid-base concept in chemistry as much as CBL instruction did. In addition to this, there are not any studies that designed the whole lectures on different real-life events, situations or problems that the students have a probability to face during their own lives next to aiming to detect and overcome students' misconceptions during teaching acids and bases concepts. For these reasons, this study will find a chance to put one more puzzle piece to the related literature about chemistry education and could be integrated to another topic of chemistry or another discipline. For aiming to overcome the misconceptions about acid and base concepts, students' learning difficulties, increase students' understanding and learning acids and bases concepts and helping students to realize chemistry concepts are highly related to real-life situations, this study will apply CBL.

To conclude, under the light of the reasons mentioned above, the purpose of this study is to compare the effects of an instruction based on case based learning with traditionally designed instruction in terms of students' understanding of acids and bases concepts and their motivation to learn chemistry. In other words, this study was designed to help students to overcome their misconceptions so that they might learn the acids and bases concepts better, make connections between the real life situations and acids and bases concepts which also improve their motivation. Moreover, as a result of case based learning, students become more motivated to learn chemistry and accordingly their understanding of the related concepts would improve which may help to overcome their misconceptions that would bring higher achievement to the students.

1.1 Statement of the Problem

The present study will investigate the effects of case based learning method in 11^{th} grade students' understanding of acids and bases concepts and their motivation to learn chemistry.

1.1.1 Main Problems

The main problem, sub-problems, and hypotheses were given in this section. The main purpose in this study is twofold: (1) to examine the effectiveness of case based learning instruction over traditionally designed instruction method on eleventh grade students' understanding of acids and bases concepts and (2) to examine the effectiveness of case based learning over traditionally designed instruction method on eleventh grade students' motivation to learn chemistry. Accordingly, the main problems could be given as the following based on the purposes mentioned above:

1. What are the effects of CBL instruction when compared to traditionally designed instruction and school type on 11th grade students' conceptual understanding of acids and bases concepts?
2. What are the effects of CBL instruction when compared to traditionally designed instruction and school type on 11th grade students' motivation to learn chemistry?

1.1.2 Sub-Problems

The sub-problems of the study were as given below:

1. Do methods of teaching (CBL versus traditionally designed instruction) make difference on the collective dependent variables of students' understanding of acids and bases concepts and motivation to learn chemistry when students'

previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?

2. Do Anatolian and science high school differ on the collective dependent variables of students' understanding of acids bases concepts and motivation to learn chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?
3. Is there an effect of interaction between treatment and school types on the collective dependent variables of students' understanding of acids and bases concepts and motivation to lean chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?
4. Do methods of teaching (CBL versus traditionally designed instruction) make difference on students' understanding of acids and bases concepts when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?
5. Do Anatolian and science high school differ on students' understanding of acids and bases concepts when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?
6. Is there an effect of interaction between treatment and school types on students' understanding of acids and bases concepts when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?
7. Do methods of teaching (CBL versus traditionally designed instruction) make difference on students' self-efficacy construct of motivation to learn chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?
8. Do Anatolian and science high schools differ on students' self-efficacy construct of motivation to learn chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?

9. Is there any interaction between treatment and school types on students' self-efficacy construct of motivation to learn chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?

10. Do methods of teaching (CBL versus traditionally designed instruction) make difference on students' anxiety construct of motivation to learn chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?

11. Do Anatolian and science high schools differ on students' anxiety construct of motivation to learn chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?

12. Is there any interaction between treatment and school types on students' anxiety construct of motivation to learn chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?

13. Do methods of teaching (CBL versus traditionally designed instruction) make difference on students' goal-orientation construct of motivation to learn chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?

14. Do Anatolian and science high schools differ on students' goal-orientation construct of motivation to learn chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?

15. Is there any interaction between treatment and school types on students' goal-orientation construct of motivation to learn chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?

16. Do methods of teaching (CBL versus traditionally designed instruction) make difference on students' intrinsic motivation construct of motivation to learn

chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?

17. Do Anatolian and science high schools differ on students' intrinsic motivation construct of motivation to learn chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?
18. Is there any interaction between treatment and school types on students' intrinsic motivation construct of motivation to learn chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?
19. Do methods of teaching (CBL versus traditionally designed instruction) make difference on students' self-determination construct of motivation to learn chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?
20. Do Anatolian and science high schools differ on students' self-determination construct of motivation to learn chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?
21. Is there any interaction between treatment and school types on students' self-determination construct of motivation to learn chemistry when students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled?

1.2 Statement of the Hypothesis

The problems mentioned above were tested with the following hypotheses. Hypothesis 1, 2 and 3 are related to main problems and the rest covers the sub-problems:

$H_0$1: There is no statistically significant difference between teaching methods when taking CBL and traditionally designed instruction into account on the population mean of the collective dependent variables of eleventh grade students' post-test scores of Acids and Bases Test (post-ABT) and motivation to learn chemistry post-test scores of each construct (post-CMQ constructs) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$2: There is no statistically significant mean difference between Anatolian and science high schools on the population means of the collective dependent variables of eleventh grade students' post-test scores of Acids and Bases Test (post-ABT) and motivation to learn chemistry post-test scores of each construct (post-CMQ constructs) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$3: There is no statistically significant interaction between the treatment and school types on the population means of collective dependent variables of eleventh grade students' post-test scores of Acids and Bases Test (post-ABT) and motivation to learn chemistry post-test scores of each construct (post-CMQ constructs) and motivation to learn chemistry post-test scores of each construct when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$4: There is no statistically significant difference between the students taught via CBL and traditionally designed instruction on the population means of the post-test scores of Acids and Bases Test (post-ABT) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$5: There is no statistically significant difference between Anatolian and science high school on the population means of the post-test scores of Acids and Bases Test (post-ABT) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$6: There is no statistically significant interaction between the treatment and school types on the population means of the post-test scores of Acids and Bases Test (post-

ABT) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$7: There is no statistically significant difference between students taught via CBL and traditionally designed instruction on the population means of the post-test scores of the self-efficacy construct of motivation to learn chemistry questionnaire (post-SE) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$8: There is no statistically significant difference between Anatolian and science high schools on the population means of the post-test scores of the students' self-efficacy construct of motivation to learn chemistry questionnaire (post-SE) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$9: There is no statistically significant interaction between the treatment and school types on the population means of the post-test scores of the students' self-efficacy construct of motivation to learn chemistry questionnaire (post-SE) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$10: There is no statistically significant difference between students taught via CBL and traditionally designed instruction on the population means of the post-test scores of the anxiety construct of motivation to learn chemistry questionnaire (post-ANX) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$11: There is no statistically significant difference between Anatolian and science high school on the population means of the post-test scores of the students' anxiety construct of motivation to learn chemistry questionnaire (post-ANX) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$12: There is no statistically significant interaction between treatment and school types on the population means of the post-test scores of the students' anxiety construct of motivation to learn chemistry questionnaire (post-ANX) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$13: There is no statistically significant difference between of students taught via CBL and traditionally designed instruction on the population means of the post-test scores of the goal-orientation construct of motivation to learn chemistry questionnaire (post-GO) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$14: There is no statistically significant difference between Anatolian and science high school on the population means of the post-test scores of the students' goal-orientation construct of motivation to learn chemistry questionnaire (post-GO) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$15: There is no statistically significant interaction between treatment and school types on the population means of the post-test scores of the students' goal-orientation construct of motivation to learn chemistry questionnaire (post-GO) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$16: There is no statistically significant difference between of students taught via CBL and traditionally designed instruction on the population means of the post-test scores of the intrinsic motivation construct of motivation to learn chemistry questionnaire (post-IM) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$17: There is no statistically significant difference between Anatolian and science high school on the population means of the post-test scores of the students' intrinsic motivation construct of motivation to learn chemistry questionnaire (post-IM) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$18: There is no statistically significant interaction between treatment and school types on the population means of the post-test scores of the students' intrinsic motivation construct of motivation to learn chemistry questionnaire (post-IM) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$19: There is no statistically significant difference between of students taught via CBL and traditionally designed instruction on the population means of the post-test scores of the self-determination construct of motivation to learn chemistry questionnaire (post-SD) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$20: There is no statistically significant difference between Anatolian and science high school on the population means of the post-test scores of the students' self-determination construct of motivation to learn chemistry questionnaire (post-SD) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

$H_0$21: There is no statistically significant interaction between treatment and school types on the population means of the post-test scores of the students' self-determination construct of motivation to learn chemistry questionnaire (post-SD) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

1.3 Limitations

a. There were four different chemistry teachers one of whom was in a different city of Turkey in order to enhance the generalizability of the study. Each teacher had different characteristics. For this reason, even if they were given training before the study began and they were instructed to obey the lesson plans given to them, since they were different people, their teaching strategies, explanations, communication skills were also a bit different which may be accepted as limitation since it may cause implementer threat to internal validity of this study.

b. Even if time and budget needed for this study were tried to be controlled, some unexpected events (spring festival in science high school and unexpected death of a teacher in Anatolian high school) caused time limitations during the study.
c. The study only included the quantitative data and different types of observations which may cause some limitations since the students and the teachers involved in the study were not interviewed as a follow up study to gather deep understanding about the study which could be collected qualitatively.
d. Although lecture hours were equated as much as possible, since there were eight classes included in this study four of which were in a different city of Turkey, there may be some limitations according to the time of chemistry courses since it cannot be arranged to give all classes at the same time.
e. As mentioned above, since the four classes of the study were in a different city of Turkey, not all of the classes were observed so that some events that occur during the lecture hours should be missed which may also be a limitation to the study.

1.4 Delimitations

The study has some delimitation that causes problems to make generalizations to the population:

a. The study took place in 100.Yıl districts of Karabük and Çankaya district of Ankara which were only portions of two cities of Turkey.
b. The study included only the 11th grade students since acids and bases concepts were thought at this grade.
c. The study included only the concepts of acids and bases.
d. The study was conducted with public high school students who were in science high schools and Anatolian high schools but it did not include general, vocational, industrial, technical or Anatolian teacher high schools.
e. This study included only four chemistry teachers.
f. The study included only 292 students from eight classes.

1.5 Definition of Terms

1.5.1 Traditionally Designed Instruction Method (TDIM)

In a traditionally designed instruction method, the lectures are designed as teacher-centered which means, teacher is in the center as the source of knowledge. According to Jonassen (1991), it is an instructional method in which students are receiving the information that is coming from the teachers and the textbooks so that they are all passive. Teachers act to the students like they have the holes in their minds that needed to be filled with knowledge (Novak, 1999).

1.5.2 Case based Learning (CBL)

Even if there are different definitions of case based learning, in this study this teaching method is defined as "a teaching method which requires students to actively participate in real or hypothetical problem situations, reflecting the kinds of experiences naturally encountered in the discipline under study" (Ertmer & Russell, 1995, p. 24).

1.5.3 Motivation

1.5.3.1 Constitutive definition

Willingness to do something or something that causes such willingness and in psychology it is defined as "the process that arouses, sustains and regulates human and animal behavior" (Collins English dictionary, n.d).

1.5.3.2 Operational definition

In this study, the cognitive definition of motivation will be considered since it includes the elements that many of researchers think as the center of motivation; "*Motivation is the process whereby goal-directed activity is instigated and sustained"* (Schunk & Pintrich, 2002, p.5). In order to understand its definition deeply, it is important to focus on the important notions in the definition:

1.5.3.3 Process

Motivation could not be observed directly but it could be inferred from understanding behaviors that result in achievement such as; choice of task, persistence, exerting effort etc. In this sense, it is a process, not a product instead.

1.5.3.4 Goals

Motivation involves goals, which are very important to reach. Goals may not be well-formulated whereas; students who possess goals have something in mind and struggle to attain those goals.

1.5.3.5 Activity

The motivational activities could be either physical or mental; physical activities require effort and persistence and mental activities require planning, monitoring, decision making etc.

1.5.3.6 Instigated and sustained activity

Since taking the first step or making the commitment were difficult to be done; deciding and begining to move toward a goal is generally very hard next to being very crucial. However, motivational processes are critically important to sustain actions (Schunk & Pintrich, 2002).

1.5.4 Motivation to Learn Chemistry

Students' interest to learn chemistry next to his/her willing to make an effort during chemistry learning (Brophy, 1998).

1.5.5 Misconception

The ideas those are different from the scientifically accepted view (Griffiths & Grant, 1985).

1.5.6 Achievement

In this study, achievement is determined by the understanding of the acids and bases concepts and in this study; it was measured by the Acids and Bases Test (ABT).

1.6 Significance of the Study

In the world, we could see a great direction to the constructivist theory in education (Pirie & Kieren, 1992; Brewer & Daane, 2002) and case based learning (CBL) is an education method that is put under constructivist theory. CBL method has many advantages on learning since since it promotes student accountability, it helps to gather prompt feedback about the lectures and it is supporting active learners who know how to study cooperatively and collaboratively in groups. Moreover, CBL aims to help students improve their higher order thinking skills (Herreid, 1994; Tarkın, 2014), critical thinking skills (Alvarez, 1990; Uluyol & Güyer, 2014; Yoo & Park, 2014) and creativity (Garvey et al., 2000; Thistlethwaite et al., 2012) next to their social skills (Yalçınkaya, 2010).

In case based learning (CBL), students work together in groups on realistic cases related to real-life so that the social skills of the students increasing while they become familiar to the real-life situations that have a chance to happen. Students also became obligated to apply higher order thinking skills and their creativity while working to solve complex, real-world problems.

According to the literature, acid-base chapter is difficult for students to learn since traditionally designed instruction method for teaching acid-base chapter is not enough that also may cause an increase in the probability of students to have misconceptions (Cros et al., 1986; Demerouti, Kousathana & Tsaparlis, 2004; Demircioğlu, Ayas, Demircioğlu, 2005; Driver et al., 1994; Lin, Chiu, & Liang, 2004; Morgil et al., 2002; Nakhleh, 1992; Ross & Munby, 1991; Schmidt,1991; Schmidt, 1995; Schmidt, 2000; Smith & Metz, 1996; Vidyapati & Seetharamappa, 1995). Students generally have difficulty in learning the definitions of acids and bases according to different theories, the reaction that occur between acids and bases and acids and bases strengths (Çetin-Dindar, 2010; Schmidt, 2000). To give an example, Schmidt (2000) emphasized the students having trouble in understanding the reaction between magnesium oxide/hydroxide and hydrochloric acid since they believed this reaction to be a redox reaction since there is oxygen in the oxide and hydroxide.

Even if different constructivist teaching methods have been applied to acid-base chapter of chemistry, this study has contributions in several ways. First of all, none of them connected the real-life situations with the acid-base concept of chemistry as deeply as in case based learning in Turkey. In other words, there aren't any studies that applied real-life situations to teach acid-base chapter through them since other constructivist methods generally use real-life situations to give examples to the situations and for enhancing the students' learning in Turkey. For this reason, this study will find a chance to put one more puzzle piece to the related literature. Secondly, in the literature, there are not many studies that aimed to improve students' motivation to learn chemistry in Turkey and there weren't any studies that also aimed to overcome students misconceptions, improve students understanding on acids and bases concepts that results in higher achievement, remedy acids and bases learning difficulties through the given real-life situation based cases and conducted the study in two types of schools. This study is the first to explore the effect of these all together. So; this study may make a contribution to chemistry teaching and other areas of practical and theoretical research by showing a way to apply case based learning on other units, subjects and disciplines. In addition to these, findings of this study could be accepted as making contribution for chemistry teachers as well as for chemistry teaching in general since all the materials used in the study and the way to apply the strategy were explained in a detailed way to be used in acids and bases concepts.

To conclude, it was believed that this study may help students to learn better, overcome misconceptions, and make connections between the real life situations and lessons about acids and bases. In addition to these, from a wider view, this study may make contributions to the literature especially in terms of chemistry education, show the ways to improve students' motivation to learn chemistry, and promote their interest in chemistry. Moreover, since as a result of case based learning, the real life problems should make students become more motivated to learn and accordingly their understanding of the related concepts should directly be improved that also consequently improves students' achievement. Furthermore, since in this study the CBL instruction was applied, this study might also help the students to improve their social skills, increase their creativity next to developing their higher order and critical thinking skills as a result.

CHAPTER 2

REVIEW OF THE RELATED LITERATURE

Students generally have difficulties in learning science (Chi, Slotta, & De Leeuw, 1994; Duit & Treagust, 1998; Harrison & Treagust, 1996). In order to overcome the difficulties, the researchers developed many instructional theories that should improve students' learning, understanding and achievement in science education (Borich, 2004; Duit & Treagust, 1998). At first, it is believed that behavioral changes in a good direction is an important evidence for learning to come true (behaviorist theory) and later it is believed that cognitive development is important for students to learn (cognitivist theory) after realizing the limitation in explaining process of behavior change in the behaviorist theory (Saettler, 2005). Although cognitive development is an important issue for students' learning, social interaction with others is not considered in cognitivist theory. For this reason, nowadays, another theory is developed that included both social interaction and the process of students' building up their own learning which is called as the constructivism. Nowadays, constructivism is accepted as the most applicable theory of learning and teaching for meaningful learning that leads students to success (Jungst, Licklider, & Wiersema, 2003; Sigler & Saam, 2006, 2007).

2.1 Constructivism

Constructivism is simply based on learners constructing their own knowledge actively by linking new knowlede to their prior knowledge (Strommen & Lincoln, 1992). In other words, constructivism accepts learners not as they are empty glasses waiting to be filled; instead, they are the active organisms searching for meaning of the new information (Driscoll, 2005). For learning to occur there is no isolated environment. Learners were interacting with the learning environment and with other learners next to their interation with the knowledge, (Dershem, Patsiorkovski, & O'Brien, 1996).

Von Glasersfeld (1993) mentioned constructivism to be a way of knowing that redefines the world we live in as a source of knowledge. This redefinition refers the reality being dependent upon the mind for its existence; therefore knowledge is constructed by mind instead of being a carbon copy of reality. When students conceptualize the reality, they need to reflect upon it, process and organize (Kılavuz, 2005). In that manner, learning becomes a process in which the learners actively build upon their own prior knowledge. For this reason, it is important for learning to be in an active environment and there must be interaction between the teacher and the students so that the learners should construct knowledge by their teachers guiding. Generally, these interactions require time since reforming and building new ideas requires small steps toward them (Driver & Oldham, 1985).

Constructivism is also based on the theories of Piaget (1968), Ausubel (1968) and Vygotsky (1978). In Piaget's (1968) theory, individuals' cognitive development is the emphasis and students come to classroom with prior ideas, concepts that needed to be developed by discovery learning, hand-on activities etc. which enables students to construct their own learning as constructivism proposed. Similarly, in Ausubel's (1968) theory, "the most important single factor influencing learning is what the learner already knows" (p.18). In other words, according to this theory, the new information should be linked with the students' prior knowledge for meaningful learning to come true that also enables students to build up the related knowledge as it happens in constructivism. According to Vygotsky's (1978) theory, the students' development of knowledge could be reached by social transformation in which the meaning of the words for the culture are shared by the group and internalized by the learner (Kılavuz, 2005) so that interaction between individuals is accepted as a part of learning that is involved in constructivism.

Accordingly, all these aspects to learning make a base to develop the new approach, constructivism. Constructivism could be thought as an umbrella for a wide diversity of theories. Since it includes all these theories, according to Lorsbach & Tobin (1992), nowadays researchers defend the idea that ione possible way to make sense of how students learn is through constructivism.

Barr and Tagg (1995) stated that the purpose of meaningful learning is not to transmit knowledge, but to create an environment that allows learners to discover and construct knowledge for themselves. In contrast to other theories, constructivism purposes to change the structure of the learning objectives and make it a learner-centered instructional environment where various points of views are represented, where knowledge itself and building of it are all collaborative next to being interactive and inductive, and where questions are respected, welcomed; in other words they are valued (Brooks & Brooks, 1993; Lebow, 1993). For this reason, the role of the learner is conceived as building and transforming knowledge.

Under the light of the description of constructivism, the role of the teacher is also redefined. According to Duffy and Cunningham (1996), teachers' role is as a guide or a coach. Teachers should assist the students to construct new knowledge by helping the students combine their prior knowledge with the new concept. Teachers must design activities that the students will have active roles which means the activities should be organized by the teacher will be student centered. Moreover, students would feel free to ask questions, search for the informations by them selves, conduct their own experiments, and try to develop their own analogies if they believe they needed, and come to their own conclusions. Thus, it can be concluded that the teachers who adopt constructivism must behave different from the teachers who adopt traditional instruction techniques. In other words, becoming a constructivist teacher was not an easy transformation since most instructors were raised by learning to teach traditionally and in an objectivist manner (Brooks & Brooks, 1993).

According to Rhodes and Bellamy (1999), teachers should act as a facilitator that is different from the role of a traditional teacher because the traditional teacher explains rather than asking as the facilitator does; a traditional teacher lectures directly from the front rather than supporting from the back as the facilitator does; a traditional teacher gives answers according to the curriculum rather than providing guidelines and creating an environment for the learners to infer their own conclusions as the facilitator does; a traditional teacher mostly gives a monologue, rather than being involved in continuous dialogue with the learners as the facilitator does.

In the literature, there are many studies that showed the effectiveness of the constructivist theory on education (e.g., Akkuş, Kadayıfçı, Atasoy, & Geban, 2003; Bukova-Güzel, 2007; Caprio, 1994; Hand, Treagust, & Vance, 1997; Jonassen & Murphy, 1999; Lord, 1999, 2005). To give an example; the study of Caprio (1994) investigated the effect of constructivist approach over the traditional lecture-lab method and the results of the study revealed the students taught by constructivist approah gathered better exam grades which were also statistically significant. In addition to that, the students taught by constructivist approach seemed more confident of their learning.

Hand, Treagust, and Vance (1997) conducted a study based on constructivist approaches to teaching science and they examined secondary school students' perceptions according to the classrooms in which these constructivist approaches were implemented change their nature as a consequence of their implementation. Study was conducted over four years involving classroom observation of students, semi-structured interviews, and open-ended questionnaires. Results of the questionnaires showed that most students enjoyed the constructivist approaches since they were involved to the lectures more actively where they were having more discussions and practical work in addition to less note-taking which brings greater understanding of the related concepts. Interview results also supported the results since during the interviews, the students mentioned to be more active in the learning process and to have a chance to see and control their own thinking. They built up true knowledge more confidently and students' confidence in terms of their understanding of science also improved. But, since this study was conducted in one school and since it was a qualitative study, the results of this study have a lack of generalization.

Similarly, the study conducted by Bukova-Güzel (2007) aimed to compare achievement on limit concept of 60 university students 31 of which were taught in a learning environment that is based on constructivism and 29 of which were taught in another learning environment that is based on traditionally designed instruction. A pretest-posttest quasi-experimental design was applied. Subjects of the study were selected by purposive sampling. Study took six weeks to be conducted and

Worksheets Relation to Limit Concept was collected to evaluate students' learning about the limit concept. These worksheets were divided into four sub-groups each with different purposes which are to assess students' skills, to assess students' viewpoints, to understand whether the students knew the pre-concept about the limit concept and to assess whether the students constructed the relationship between the limit concept and the other branch of science. The results of the study exposed the experimental group (constructivist teaching environment) to be more successful when compared to control group (traditional teaching environment). Results of the study found that the control group students could have misconceptions about limit concept whereas experimental group students did not. This study also revealed that the constructivist learning approach improved students' high level thinking skills which O'Callaghan (1998) also mentioned in his study. But, this study does not include any control of threats to internal validity and there is no information about the power, effect size, alpha and beta values which cause a limitation. For this reason, we could not directly conclude if this study is statistically or practically significant. In addition to these, the sample size is not large enough to make generalization to a larger population. The generalization could be when the population has similar properties to the sample of this study.

Although there are many studies that showed the positive effects of constructivism on education, there are also some studies that indicated its negative effects. For example, Brophy (2006) revealed constructivism to be ineffective in a classroom, and recommended to conduct more research in this area before concluding constructivism to work properly. Similarly, Reid (2008) found constructivism confusing and not effective all the time because if the new knowledge is stored linked correctly to prior knowledge, then we have meaningful learning but if new knowledge is linked incorrectly, then misconceptions began to occur in students' mind or if knowledge is stored unlinked, this results rote learning.

Liang and Gabel (2005) examined the effect of Powerful Ideas in Physical Science (PIPS), a new constructivist curriculum model, to enhance 121 prospective teachers' understanding of Nature of Matter unit of chemistry. The study took four weeks to be completed. The design of the study was a non-equivalent pretest–post-test control-group design. Data were collected by students' past science achievement course grades at the beginning of the interference, conceptual understanding level that was measured by the final course grades of the students, and their attitudes measured by the Chemistry Attitude Survey (CAS) that was developed by Hassan and Shrigley (1984). After quantitative data were collected by these instruments, at the end of the study interviews were also conducted with 12 participants of the study. The results of the study showed that the PIPS approach did not show statistically significant supremacy in terms of increasing students' chemistry concept understanding or supporting students' positive attitudes toward chemistry overall. The authors of this study concluded that these results revealed since there was not enough time for changing students' motivation and they suggested that a method that might increase students' higher order thinking skills and include real-life problems should be appropriate. This study's results were important since a large effect size was found. Thus, the findings of the study have both statistical and practical significance. But, in this study no reliability and validity measures of the instruments were provided. Also, the instrument used to collect data about students' attitudes was an old instrument which might be out of date in terms of the chemistry concepts that needed to be taken into account. In addition to that, no threats to internal validity were discussed even if a nonrandom design was applied. The most common threats to internal validity might be students' characteristics, attitudes of the subjects and instrumentation for this study.

There are many teaching strategies developed based on constructivism after the science education reform such as learning cycle, problem-based learning, role playing, case based learning, discussion, demonstration, etc. each of which have their own contributions to improvement in students' learning (e.g., Baddock & Bucat, 2008; Lee & Nelson, 2005; Tarhan, Ayar-Kayali, Ozturk-Urek, & Acar, 2008).

For example, a constructivism based method; concept mapping was applied in the study conducted by Lee and Nelson (2005). This study aimed to compare two types of concept maps' (generative vs. completed) and the amount of prior knowledge' (high vs. low) effects on well-structured and ill-structured problem-solving performance that are related to real-life. Volunteer sampling was applied to determine 44 undergraduate students in a university. A pre-test including ten multiple choice questions were administered to these students at the beginning of the instruction. Then, the pretest scores were applied to form four subgroups. A well-structured problem-solving test and an ill-structured problem-solving performance test were applied at the end of the instruction as a posttest. The internal reliability of the well-structured problem-solving test was .84. For the ill-structured problem-solving performance test was evaluated by raters with a Kendall coefficient of .89. The collected data was analyzed by MANCOVA. The analysis results showed that no significant differences were found on ill-structured problem-solving performance among the groups. The researchers emphasized that a sample size was required to generalize the result would be at least 72 with alpha set at .5, and power at .8, effect size with .1 to be regarded as a large effect. But they suggested applying more real-life problems for further research since they took students' attention much more. So, although the design of the study was appropriate, the small sample size was a limitation for generalization. Thus, it would be better to apply real-life problems on a larger sample size for further research.

Another study conducted by Tarhan, Ayar-Kayali, Ozturk-Urek, and Acar (2008) made a study on 9th grade students to investigate the problem-based learning (PBL) teaching strategy's effect on students' understanding the chemistry topic of intermolecular forces. For this reason, a pilot study was conducted with 150 9^{th} grade students from a high school. These students were given a pre-test that was developed by the researchers of this study. By the help of this post-test, the students' prior science knowledge was found to be the same. After the implementation, learning was evaluated by a different post-test which was also developed by the researchers. Then, as a follow up study, researchers made interview with the failed students related to the post-test results. The validity of the questions related to interviews, the test were provided by a group of tutor that consists of a chemistry teacher educator and high school chemistry teachers. After the pilot study, the study was conducted on 78 9^{th} grade students. Similar to the pilot study, both the pre-test and post-test were given to the students. There was only one control and one experimental group including 38 and 40 students respectively. The reliability of these tests was determined as .72 for the pilot study and .84 for the real study. After the study was completed, a questionnaire about students' beliefs about the PBL which was formed by Cooke and Moyle (2002) was modified and applied by the researchers of this study. The results of the study showed that control group had some misconceptions about intermolecular forces topic. But in this study case based learning that has some more advantages than the other studies will be studied which is finding a place in science education recently. In addition, experimental group had higher scores on the post-test than control group. The interview results showed that students believed the problems to be a part of real life and related to their pre-knowledge; PBL increased their communication skills; the small group discussions provided during PBL instruction give a chance to be active participants to all students in this study; but they found PBL instruction taking so much time. For this reason, the researchers concluded that its application seems to be difficult and PBL takes more time. This study is important since, the interview results showed that the students also found methods based on constructivism effective for their learning. But, although results of this study revealed statistically significant results in favor of experimental group, the power and effect size of the study was not mentioned. When students' scores from pretest and posttest were compared, it is clear that this method did not increase students' achievement so much. For this reason, this study does not have practical significance. The reason of this result might be because of not choosing the appropriate design for this study. The analyses were done by t-test analysis which was not appropriate. The pre-test and post-test used in the study were not the controlled if they were equal forms or not and this study did not control ant threats to internal validity. For this reason, it is possible to explain the significant statistical difference according to one of these threats. Most possible threats that might rise in this study were subject characteristic, instrumentation and attitude of the participants. This study might be conducted with a more appropriate design to evaluate the effect of PBL or a more appropriate method that has similar contributions but does not take so much time should be applied in the future studies.

Accordingly, it is clear that the methods based on constructivism that applied to students had some general problems. (a) Many of these studies did not control effect size or power; (b) appropriate designs or sample sizes were not selected; (c) threats to internal validity were not controlled. Because of these three limitations, there is a need for a more effective design to be applied that takes medium time to be applied. In addition to these, real-life related problems should be applied for taking students' attention and meaningful learning. Under the light of these studies, this study will apply a method based on constructivism; case based learning and these gaps in the literature should be filled by this method.

2.1.1 Case based Learning

Case based learning (CBL) as a teaching strategy and curricular design began to be discussed in the 20th century schools of education, business, law and medicine. According to Knowles (1998), its roots are seen in ancient Greeks, Chinese or Romans for providing the individuals a cart to explore a concept and to identify the situations. Similarly, for Sichenze (2004), although case based learning has a long history, the next centuries had changed their focus to teacher-centered methodologies which caused case based learning to lose its celebrity in education for a long period of time. As the constructivist theory become popular again, case based learning has become a core teaching approach once again since it has a potential to promote active learning and it is modeled upon a student centered philosophy.

The returning of case based learning (CBL) to schools has begun with the Harvard Business School being the pioneer (Barnes, Christensen, & Hansen, 1987) and has been shown to be an extremely effective way of teaching business administration in business schools. After the positive effect in business schools have been realized, medical schools also began to adopt CBL into their curriculum. It is now beginning to find a place in science teaching since The Faculty of Science at The Chinese University of Hong Kong has become the pioneer to introduce this approach in the teaching of the material sciences and other science subjects to university students (Wasserman, 1994).

Case based learning (CBL) is accepted as a form of problem based learning (Barrows, 1986; Magnuson & Fu, 2014; Rosenstand, 2012) which has been evolved from a health science curricula over 30 years ago at McMaster University in

Couldada (Boud & Feletti, 2008). The reason of accepting case based learning as a model of problem based learning is because of their similar characteristics. They both suggested working in small groups cooperatively, class discussions, working on a daily-life problem, constructing owns knowledge with the help of students' prior knowledge and resources provided by the teacher, discover learning that is meaningful to students and apply scaffolding and supported by the same educational theories conceptually which are Piaget (1968), Bruner (1966), and Vygotsky (1978). According to Albanese (2000), in both theories, the learning environment promotes a self-governing learning attitude for students and let teachers to support their students to take for their own learning responsibilities. In addition to adding responsibility to students, it shifts the teacher responsibilities since the role of the teacher is now acting as a facilitator, providing advice and guidance with learning resources instead of interrupting and directing the students.

Although there are many similarities between case based learning (CBL) and problem based learning (PBL), there are also some main differences. The most known difference is the time. According to Hay and Katsikitis (2001), the cases given to the students that are in case based learning environment take one and a half hour or less whereas, the problem based learning cases took days to finish. The second difference is that, in case based learning, the directive feedback and corrective assistance are applied whereas in problem based learning, no directive feedback or corrective assistance is used. According to Savery (2006), problem based learning is different from case based learning because case based learning diminishes the students' role in determining their goals and the outcomes for the problem since the cases tend to be better defined and it is important for students to have the ability to both define the problem and develop a solution which is provided by problem based learning.

Furthermore, the teachers' role is different in case based learning than in problem based learning because in case based learning, teachers needed to provide guidance, feedback and suggestions on whether the objectives of the related lecture have been met, so teachers role is more close to instructors and coaches whereas in problem based learning teachers role is acting as a tutor who never provides any information on the problem since this is the responsibility of the learner. For these reasons, although problem based learning and case based learning are similar, in reality they are different methods in favor of CBL because of its feasibility in education.

There are numerous definitions and interpretations of case based learning in the literature. To give an example, Jonassen and Hernandez-Serrano (2002) defined CBL as a kind of technology that could be found in more developed systems like systems that apply intelligence during tutoring. In the same vein, Sichenze (2004), case based learning could be defined as “the learning that include real life problems or situations, and that are drawn from events or research” (p.54). A key point to designing, implementing and assessing the student outcomes achievable with case based learning (CBL) is to determine the definition that best fits this studies’ teaching philosophy and institution's mission. For this reason, although there are different definitions of case based learning, the most common used definition in the studies was “a teaching method which requires students to actively participate in real or hypothetical problem situations, reflecting the kinds of experiences naturally encountered in the discipline under study” (Ertmer & Russell, 1995, p. 24). For this study, in order to put one definition into the core, CBL instruction could be simply defined as an instruction that aimed to create a bridge between theory and practice (Engle & Faux, 2006) by asking students about real-life situations to want them to connect the concepts (Kurz et al. 2005) of the unit of interest.

The reason of different definitions could be because of the content of a case or its scope, a specific teaching style consisted with it and the range of its use within a course, or a program (Erksine, Leenders, & Mauffette-Leenders, 2003) since CBL engages students in discussion of daily life examples that are introduced as the cases (Merseth, 1991). Another reason might be that of different usage of purposes, fields and forms of the cases that are used in case based learning. For this reason, the case definition should also need to be done correctly.

In the literature, there were also several definitions for cases. According to Apaydın (2008), case should be defined as the following: “A case is a description of an actual situation, commonly involving a decision, a challenge, an opportunity, a problem or an issue faced by a person, or persons in an organization" (p. 9). For Shulman (1992), "a case has a narrative, a story, a set of events that unfolds over time in a particular place" (p. 21). Wasserman (1994) and Herried (1997) defined the characteristics of the effective cases for learning as; (a) the case content and the instructional goals or objectives should be in coherence with each other, (b) the case should include a story that focuses on an interesting issue, (c) the case should be appropriate to its readers' age or level, (d) it should be well-written, (e) the case should be stated clearly and the dilemma should be explained without resolving it, (f) the case should be directly related to the reader, (g) the case should arouse conflict, (h) the case should impress decision making and (i) in order to be used in several applications, the case should be general enough. According to Hudspeth and Knirk (1989), "case materials should have enough background information and detail so that they are believable" (p. 31). So, it is important to note that the given cases should be well-structured examples of the situations that reflected real-life situations.

Researchers from several areas identified positive effects of using cases for teaching and learning. For example; according to Spiro and Jehng (1990), cases are considered a valuable support for students' learning that enhances learning by the help of asking questions and getting help from peers. As a result, the students will be in a social interaction which will then increase students' communication skills. Also, in order to build new knowledge, the cases provide a meaningful source for learning, with an unforgettable anchoring experience. By the help of the daily-life related cases, students should find a chance to gain experience on how to solve real life problems. Cases could also help learners improve critical thinking skills (Alvarez, 1990; Bennett 2010; Uluyol & Güyer, 2014; Yoo & Park, 2014) since they were exploring and examining their opinions while studying on the information provided (Jonassen, 2002) while studying on the given cases. For these contributions, application of cases during teaching is an important issue that needed to be taken into account. The major method that an insert cases into teaching is defined as case based learning.

Different studies have been conducted on the effect of case based learning. The results showed that case based learning has a positive effect on students' learning

(Cornely, 1998; Du, et al., 2013; Harrington, 1995; Horzum & Alper, 2006; Jonassen, Mayes, & McAleese, 1993; Merseth, 1991; Sendur, 2012; Peplow, 1996, Yadav, et al., 2014). Jonassen, Mayes, and McAleese (1993) stated that using CBL let learners to become wholly absorbed in meaningful learning and to improve metacognitive processes. Cornely (1998), Savery (2006) and Rybarczyk et al. (2007) concluded that CBL engage the learners in higher-order thinking such as analysis and synthesis. According to Garvey et al. (2000), for applying CBL, students' creativity skill was also improving since they needed to apply their decision-making skills while working on the cases. Harrington (1995) suggested that, CBL is based on the consideration that knowledge is constructed on prior knowledge, paired with experience then transformed, evolved, and became consequential, thereby, "provides students with insight into alternative solutions from various perspectives" (p. 203).

According to Rosenstand (2012), case based learning is better when different disciplines were combined since it is practiced better with interdisciplinary cases. According to Merseth (1991), CBL is suitable to teach the essential skills of analysis and to enhance students' decision making, their critical thinking and their ability to solve problems. According to Yoo & Park (2014), students' communication skills and problem solving ability increased next to students' motivation (Sutyak, Lebeau, & O'Donnell, 1998) which is a result of students' feeling involved when they are a part of the real problem. According to Dori and Herscovitz (1999) and Yalçınkaya, Boz and Erdur-Baker (21012) case based learning was also found to be enhancing students' motivation since there were real life situations in the instruction. Moreover, the study conducted by Çam & Geban (2013), Angeli, (2004), Yalçınkaya et al. (2012) and another study conducted by Yalçınkaya (2010) found that CBL had a positive effect on remedying students' misconceptions as it was said in the study conducted by Herreid (1994).

The purpose of the study conducted by Horzum and Alper (2006) was to determine single and common effects of teaching methods (case based learning and traditionally designed instruction method), cognitive style (field dependent/independent) and gender on 70 secondary school student' achievement in pollution of environment unit of science. 35 of the students were taught by case based learning (experimental group) while other 35 students were taught by traditionally designed instruction method (control group). The study took four weeks to be completed. At the beginning of the study Group Embedded Figures Test was applied in order to assess students' cognitive style and their analytical abilities. At the end of the lectures, an achievement test with 10 open-ended questions was applied to each group. However no reliability or validity values were provided for any of these instruments. The results of the study revealed that case based learning is more effective than traditional learning. The study is statistically significant according to the results gathered from SPSS analysis and it is also practically significant because, the mean of post-test scores of the achievement test for the experimental group is 62.86 whereas it is 44.00 which means, application of case based learning is very effective when compared to traditionally designed instruction method. In the study, the threats to internal validity were not mentioned in the study. Possible threats that might arise because of the design are attitudes of the participants, instrumentation and subject characteristics mainly. The authors of this study suggested designing more instructions based on case based learning in other science areas for meaningful learning and comparing its effect with other constructivist methods.

As it was suggested to study case based learning in another science area, Rybarczyk (2007) conducted on an experimental research that examined the case based learning effect on students' learning gains and their higher-order thinking skills when compared to traditional instruction on cellular respiration concepts of biology. There were two groups in this study the –CS (the class case study was not implemented) and +CS (the class case study was implemented). In this study there were a total of 157 students; 63 of which were in the class that case study was not implemented and 94 of which were in the class the case study was implemented. There were pre-test and post-test next to a survey used as a post-activity to collect data from the students. The pre-test and post-test were formed to evaluate the content comprehension that focused on crucial molecules, cellular organelles, and processes which were involved with cellular respiration and the questions of both tests were not identical even if they consist of similar content in order to reduce the pre-test sensitization. And the survey was used to evaluate students' perceptions of their learning experience and their collaboration level with other students which included a likert scale and open-ended questions in it. Moreover, since this study was designed to measure students' learning gain; the students' misconceptions were considered during the preperation of the instruments. In addition to these, the teachers of the study were also given a post-survey in order to have an idea about their perceptions and to get feedback about the study. The collected data from pre and post-tests were analyzed by the chi-square test so that it was determined whether a relationship existed between student performance and their groups and open-ended survey questions were grouped as some common themes were found to produce a categorical scheme for the students' perceptions. The results of the study showed that students implemented with case studies (+CS) scored significantly higher than the students implemented without case studies (-CS) with an effect size of d = 0.98 which was very high and showing the study to have a practical significance too. In addition to these results, the students in the +CS group reached a significantly higher learning gain when compared to -CS group. Furthermore, since one of the goals of this case study design was to correct students' misconceptions, some misconceptions were detected by case study implementation and the students in the +CS group had corrected their misconceptions with a higher rate when compared with students in -CS group. However, the chi-square results showed that this higher rate of correction of misconceptions in +CS group were not significant statistically. So, it was concluded that the data collected from this study did not provide sufficient evidence to prove case study to clarify students' misconceptions. Moreoever, in terms of students' higher-order thinking skills, it was found that the students that were implemented by case study performed better on the post-test question when compared to the students that were not implemented with case study. Next to these results of the study, the results gathered from the teacher surveys provided positive feedback about the study. This study results made a contribution to the literature since it showed a stronger evidence about case based instruction to improve students' higher order thinking skills by demonstarting these skills on a post-test assessment. In this study it was also adviced for future studies to investigate the effectiveness of the case studies when they were used in a course, examine whether CBL leads to long-term content retention, or study on finding the best way to detect studens' misconceptions by applying CBL.

Under the light of these recommendations, a study conducted by Hutchinson (2000) tried to examine the effectiveness of the case studies when they were used in a course and examine whether CBL leads to long-term content retention. In addition to this, the effect of CBL instruction on students' critical thinking skills next to the effect of CBL in improving students' understanding of fundamental chemistry were also examined. There were 221 students involved in this study who were taking the general chemistry course and the assignments throughout this course were all formed with the aim of challenging students to explain the logical linkages between the experimental observations and theoretical models. Thus, during the class hours, the teacher made the students be involved in the inductive reasoning process so that the students tried to learn the way the chemistry concepts' development by applying observing, questioning and model building accordingly. The data were collected through quizes done at the beginning of each lecture, the final exam conducted after the implementation and by a survey for evaluating the case base implementation at the end of the course. According to the study results, students' understanding related to the chemistry concepts involved in the course were improved and the students generally corrected their misconceptions or mistakes they did in the quizes that were applied before the lecture hours when compared to the final exam results. In addition to these, the survey results showed that case based instruction affected students' opinions in a positive way since they mainly thought about their understanding and retention of the chemical concepts were enhanced next to their problem solving skills, their ability to read, their skills to analyse new materials, their success in studying chemistry that also leads to improved critical thinking skills.

As the study conducted by Rybarczyk (2007) recommended to study on finding the best way to detect studens' misconceptions by applying CBL for future studies, a study conducted by Ayyıldız and Tarhan (2013) studied on the students' understanding of gases, liquids and solids and examined the effect of case based instruction on these concepts next to CBL instruction's effect on detecting students' misconceptions and their attitudes towards chemistry lessons. There were 52 students in this study and it was a the pre-test post test control group design since the study was conducted on intact groups. The instruments used in this study were the Attitude Towards Chemistry Lesson Scale (ATCLS) including 25 likert-type items, Prerequisite knowledge test which includes 30 multiple-choice items and the Achievement Tests for gases,The Gases Achievement Test (GAT); for liquids, The Liquids Achievement Test (LAT), and for solids, The Solids Achievement Test (SAT) which were developed to determine students' understanding of gases, liquids, and solids concepts. These achievement tests included multiple choice questions next to open-ended questionsin which students were required to explain their reasons for their answers they gave to the multiple choice questions. The Prerequisite knowledge test and the Attitude Towards Chemistry Lesson Scale (ATCLS) were given to the students as pre-tests and the achievement tests (GAT, LAT and SAT) were given to the students as post-tests next to the Attitude Towards Chemistry Lesson Scale (ATCLS) once again. During the implementation, the experimental group students were taught by case based instruction whereas the control group students were taught by traditional instruction by the same teacher. There were a total of eight cases designed for this study. After the study was finished, the collected data were analyzed by independent sample t-test. According to this study results, it was revealed that the difference between control and experimental groups was statistically significant in terms of the mean scores. In addition to that, according to the results obtained from the Attitude towards Chemistry Lesson Scale results, it was found that case based instruction significantly improved students' attitudes towards chemistry lessons positively. Moreover, as the achievement test results were analyzed, it was found in this study that the misconception related to gas, liquid and solid concepts in the experimental group were less than the control group and it was also revealed that the students in the experimentasl group understood the related concepts more than the control group students according to the achievement tests' results. Even if there were so many positive results of this study, it also had some limitations. First of all,its generalizability was very low because of the small sample size. In addition to that, since the statistical method applied in this study was very simple, it threatens the study since there might be many uncontrolled variables and the rate of making error also increased. In addition to that, no power analysis or the effect size were given for the results of this study which also lowers the study's validity and reliability.

Similar findings were found in another study conducted by Çam and Geban (2013), the effects of CBL on students' understanding of the solubility equilibrium concept was compared with the traditionally designed chemistry instruction. For this reason, two intact classes of the same teacher with its 63 eleventh grade students were used as the sample of the study. One of these intact groups was randomly assigned to be the experimental group whereas the other one assigned to be the control group. For the experimental group, CBL instruction was applied in which real life cases were discussed in small group discussions and in the control group traditionally designed chemistry instruction methods was applied in which the lecturing teaching method was applied on students. The data were collected by Solution Concept Test (SCT) which was developed by Önder and Geban (2006) in order to evaluate students' understanding on solution and solubility concept with a reliability coefficient of 0.72. In addition to this instrument, Solubility Equilibrium Concepts Test (SECT), with a reliability coefficient of 0.66 that was also developed by Önder and Geban in 2006 in order to measure students' understanding on solubility equilibrium considering misconceptions was used to collect data from the subjects of this study. Another instrument Open-Ended Solubility Equilibrium Concept Test (OSECT) which was developed by the researchers of this study was also applied to collect data from the students for the same purposes as the other two instruments. Reliability of the instrument was found 0.87. For analyzing the data collected by SECT, Two-Way Analysis of Covariance (ANCOVA) was carried out. According to its results, the students in the experimental group showed higher performance when compared to the control group students. Also, students' prior knowledge was found to make a statistically significant contribution to understanding solubility equilibrium concepts. Moreover, there was no significant difference between the performance of males and females or there was no interaction between treatment and gender difference. Data collected by OSECT were also analyzed by another two-way analysis of covariance. According to its findings, the difference between the experimental group mean OSECT scores and the control group OSECT scores were statistically significant in favor of the experimental group. Furthermore, both open-ended and multiple choice concepts test results indicated that experimental group students when compared to control group students. Thus, according to the results of this study, CBL instruction was found to be more effective for students in terms of students' understanding of the solubility equilibrium concepts when compared to traditionally designed chemistry instruction. In addition to these, some misconceptions related to solubility equilibrium were detected and eliminated thanks to CBL instruction. For this reason, this study had contribution on not only the chemistry teaching by proving CBL instruction's effect on students' understanding of another topic, solubility equilibrium; but also on determining and overcoming students' misconceptions on the related topic by applying CBL since the cases in the study were developed by taking students' misconceptions into account. However, in this study there were again some limitations. Since the number of students was not very high, generalizability of the study was lowered. In addition to that, the ways to prevent internal validity threats for this study were not mentioned which would be better if the ways of controlling these threats were introduced for further studies.

Another study was directly studied on the effect of CBL on detecting and overcoming students' misconceptions in terms of chemical kinetics which was conducted by Yalçınkaya et al. (2012). The sample of this study was consisted of 53 high school students of a public school in which the intact classes were randomly assigned to be experimental and control group. The control group was implemented traditionally whereas the experimental group implemented by the CBL instruction. Data was collected from both groups by using Reaction Rate Concept Test (RRCT) which was developed by Taştan in 2009 to measure students' understandings in chemical kinetics considering students' alternative conceptions or conceptual difficulties revealed by previous studies and semi-structured interviews which was a follow-up study aimed to determine the progress in students' alternative conceptions in chemical kinetics. The reliability coefficient for RRCT was found to be 0.78 and the treatment verification was provided by a checklist prepared by Yalçınkaya (2010) and it was found to have a high consistency between two investigators (80%). The collected data were analyzed by the independent samples t-test and ANOVA. The results of both concept test and the interviews found the students in the experimental group to have greater understanding of the concepts of chemical kinetics when compared to control group. In addition to that, experimental group students' misconceptions related to the chemical kinetics were found to be lowered more when compared to control group students. It was advised for the future study that CBL instruction might be conducted on other subjects and on different grade levels in high schools with larger samples since the sample size for this study was low that lowers the generalizability of the study. Furthermore, it was also adviced to study the effect of CBL instruction students' motivation, their critical thinking skills and their academic achievement could be investigated in the subject area of chemistry.

A similar study conducted by Sendur (2012) tried to investigate the effect of CBL instruction on students' chemistry achievement related to gas laws. In this study, the sample was selected from the freshman students of an engineering faculty in a university. By applying non-equivalent control group design, 62 students were randomly assigned to be in the experimental or control group and the experimental group students were instructed by CBL whereas the control group students were instructed traditionally. Data was collected by an achievement test related to Gas laws (Gas Laws Achievement Test) which has a reliability of 0.82 Cronbach alpha value. In addition to this test, semi-structured interviews were conducted and for calculating its reliability, the percentage agreement was applied which was measures to be 0.89. A one-way ANOVA test was conducted to examine the data collected for this study. According to the results, experimental group was found to be more successful in terms of gas laws understanding than the control group. In other words, there was a significant mean difference between both groups in terms of their achievement in the Gas Laws Achievement Test (GLAT). However, the mean of the post-test scores for the GLAT was 13.63 whereas it was 10.13 for the control group which was not very high. Moreover, the interviews' analysis revealed experimental group students to be better in relating gas laws with daily life examples when compared to control group students and they perceived case based learning as enjoyable and interesting so that it was concluded from this study by Sendur (2012) that the experimental group students were more motivated than the control group students. In addition to these findings, there were also some limitations detected for this study. Firstly, although the design of the study was appropriate, the small sample size was a limitation for making generalization. Secondly, even if the researcher mentions about students' motivation, there was not any test to evaluate students' motivation and thirdly, no internal validity threats were controlled during this study. To conclude, although this study found CBL instruction to be statistically significant in terms of students' understanding of the related concepts when compared to traditionally designed instruction, there was no practical significance of this study because of the difference of the mean scores being a bit low. Also, for further studies, in order to gather significant results on students' motivation, there should be an instrument included or designed into the study for measuring CBL instruction's effect on students' motivation even if there were a few studies that measure the relationship between case based learning and motivation directly in the literature.

Under the light of the suggestion above, another study conducted by Tarkın (2014) also aimed to study on the effect of CBL instruction on students' understanding of electrochemistry concepts and its effect on students' motivation. In addition to these, this study also studied on students' attitudes toward chemistry and chemistry self-efficacy beliefs of the students. There were 113 students involved from a high school in the study and Electrochemistry Concept Test, Attitude toward Chemistry Scale, High School Chemistry Self-efficacy Scale and Chemistry Motivation Questionnaire were administered to the students in both groups as pre and post tests to collect related data. In addition to these, to gather deeper information about students' understanding follow-up interviews were also administered with twelve students next to a feedback form to get students' opinions about CBL. Even if this study included CMQ, only two constructs of this questionare, intrinsic motivation and relevance of learning chemistry to personal goals, were applicable for this study instead of all five constructs of CMQ. The data were analyzed by applying MANOVA statistics next to inductive analysis of the collected qualitative data. The study results showed CBL instruction to be effective in improving students' understanding of electrochemistry concepts, their attitudes towards chemistry and students' intrinsic motivation to learn chemistry which was also supported by the qualitative data analysis.However, in terms of students' willingless to be involved in chemistry learning for reasons such as goals, there was not found any significant difference between both groups which was inconsistent with the related literature. In addition to these, in terms of students' self-efficacy for cognitive skills and chemistry laboratory, again no significant mean differences were found. However, the study had some limitations. First of all, this study had been implemented in only one school which lowers the generalizability of this study. Second of all, the sample size was only 113 students which was a small size to conduct MANCOVA inferential statistics in reality. Third of all, the power and the effect size of this study were not discussed as deeply as needed. They were only discussed for understanding of electrochemistry concepts, attitude towards chemistry and intrinsic motivation and effect size was mentioned indirectly.

Similarly, another study conducted by Yalçınkaya, Boz and Erdur-Barker (2012), 45 high school students were examined in order to determine whether CBL instruction had an impact on enhancing high school students' motivation towards chemistry. This study was also conducted in only one school with two intact classes that were randomly assigned to be the experimental and control group. The experimental group students were instructed by CBL whereas the control group students were instructed traditionally. Then, in order to examine students' motivation towards chemistry; Motivated Strategies for Learning Questionnaire (MSLQ) that has six constructs in it (intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, test anxiety) was administered to both groups of students as pre- and post-tests to measure their perceived motivation. The collected data were analyzed by One-way MANOVA based on the gain scores of the students and follow-up ANOVAs based on students' gain scores were also performed in order to find the effect of treatment on each dependent variable separately were applied. According to the results of the study, CBL instruction was found to be effective for promoting students' motivation towards chemistry. In other words, analysis of the study indicated a significant effect of treatment on students' perceived motivation. However, when the follow-up ANOVAs were analyzed, it was seen that there was no statistically significant differences between the groups in terms of intrinsic goal orientation and test anxiety. To conclude, this study made a contribution to the literature since there were a few studies conducted for measuring the effect of CBL on students' motivation directly. In addition to these, this study studied on students' motivation by considering six constructs related to students' motivation which explained students' motivation through a wider window with these indicators. However, since MANOVA analysis needed for higher samples to provide more accurate and realistic results, this study has a limitation. In addition to this limitation, internal validity threats were also not mentioned which would decrease the study's validity. In addition to these, there should be an interview as a follow-up study to detect the reasons of intrinsic goal-orientation and test anxiety scores found to be insignificant. Thus, for the future studies, it would be better if the study would be conducted with a larger sample to increase generalizability of the study, the ways used to control threats to internal validity were mentioned and a follow-up interview was conducted after the implementation for gathering more proofs to the study.

To conclude, there are different areas that CBL seemed to be effective. They are mainly medical, law, education and business. When it comes to science education, case based learning is generally applied to biology related courses, however little is known about its application in chemistry which will be one core reason of applying case based learning in this study. Moreover, according to the literature, CBL instruction's effect on students' achievement and motivation could not be ignored. Thus, it could be said for the case based learning instruction that, during CBL instruction, students find a chance to be actively involved in their learning process by choosing or deciding on their priorities and for CBL instruction to be more effective, real-life situations were included where different disciplines were combined which all together improve students' motivation next to their understanding.

2.2 Motivation

Twenty one years ago, the *Handbook of Research on Science Teaching and Learning* (Gabel, 1994) was published. In this handbook, the term *motivation* appeared only three times. From that time, motivation has become to be the center of the psychologists and scientists as being one of the most important variables that affect learning. Now, the present *Handbook* the term *motivation* is appeared in a greater value.

Motivation is defined as “a process for goal-directed activity is instigated and sustained” (Schunk & Pintrich, 2002, p.5). Koballa and Glynn (2006) stated that, motivation is one of the construct of the affective domain. A present view is that, the “affective dimension is not just a simple catalyst, but a necessary condition for learning to occur” (Perrier & Nsengiyumva, 2003, p.1124).

Sometimes everybody feels unmotivated to complete a task, learning a concept, a given work etc. and if a person is unmotivated, that means, s/he may certainly fail in doing a task. Brophy (2000) indicated that, “motivation to learn is a competence acquired through general experience but stimulated most directly through modeling, communication of expectations, and direct instruction or socialization by significant others” (p.5).

Motivation cannot be separated from teaching so that teachers should think about students’ motivation and include motivational aspects of their teaching into their lectures in order to be sure to make assignments attractive to all students and, while doing so, motivate them to be involved in the learning process. In other words, teachers could motivate their students by recognizing them better and finding the best strategies for their students to learn. This should raise their students’ own motivation by teachers’ strategies like teaching method, his/her rewards or punishments, grades etc. to teach better. It does not mean that students may not motivate themselves without an effect from their environment. Actually, everybody has a power to motivate their own selves.

Schunk and Pajares (2001) emphasized each student to be seen as supporting a self-regulating system which influences his/her beliefs and helps in the development of his/her own motivation that allows behavior both cognitively and effectively. Moreover, there are more than five crucial constructs within this self-regulatory system which contributes to students' learning motivation (Bandura, 2001; Schunk, 2001).

Similarly, Schunk (2000) proposed that five motivational constructs that have core roles particularly for motivating the students. These are; self-efficacy, anxiety, goal-orientation, intrinsic /extrinsic motivation, and self-determination. Each construct has their own influence directly on students' motivation and indirectly on meaningful learning of students.

2.2.1 Motivational Constructs

Researches showed that motivation is an important component for learning to occur (Maehr, 1984; Schunk & Pintrich, 2002). Its effect on students' engaging in the learning process could not be deniable. Thus, during the last quarter of the twentieth century, researchers developed different theoretical approaches that emerged many motivational constructs (e.g., social cognitive theory developed by Bandura, 1986); self-determination theory developed by Ryan & Deci in 2000, attribution theory developed by Weiner in 1992, etc.). Each theory defined motivation from a perspective including different constructs that revealed their relation. From these researches, five common motivational constructs are revealed which are intrinsic/extrinsic motivation, self-efficacy, goal-orientation, self-determination and anxiety.

2.2.1.1 Self-Efficacy

The second construct on motivation is the *self-efficacy*. Bandura (1986) defined self-efficacy as belief in one's own abilities and capabilities to organize and perform the courses of action that were required to produce the given attainments. Bandura (1997) argued that self-efficacy beliefs are important determinants of whether the students will spend effort on a task and insisted on the face of difficulty. A person that has high self-efficacy, try tasks and insist on them regardless of the tasks difficulty levels. The people who have low self-efficacy will not show much effort on a task and will give up easily. For this reason, motivational impact of self-efficacy could be concluded to be dramatic (Shunk & Pintrich, 2002) because, if the students' self-efficacy perceptions are high, they will participate in the tasks that foster the improvement of their skills and capabilities. Thus, these students could be concluded to be motivated to learn because of their high self-efficacy perceptions. On the other hand, if students' self-efficacy perceptions are low, then they will not participate in new tasks which might provide their skills to be developed.

There are many studies showed the relationship between self-efficacy and students' achievement that was a result of students' improved understanding (e.g., Carroll et al., 2009; Chemers, Hu, & Garcia, 2001; Greene, et al., 2004; Silbereisen & Sharma, 2007; Zimmerman & Bandura, 1994; Zusho & Pintrich, 2003). The study made by Carroll et al. (2009) studied on the structural relationship among self-efficacy, aspirations related to academy, and omission on the academic achievement. The sample of the study was 935 students from ten schools in two Australian cities. In order to collect data, children's self-efficacy scale was used that aimed to determine students' self-efficacy degree and academic achievement of the students was assessed by using mid-year school grades. This research showed that there is a direct and strong relationship between students' self-efficacy and academic achievement.

Similarly, another study made by Greene et al. (1994), a model was tested to explain the effect students' perceptions of classroom structures on their self-efficacy, instrumentality, and academic achievement. The study was conducted on 220 volunteer high school students from English classes. 38-item likert scale Survey of Classroom Goals Structures was administered to the students first, second to measure students' confidence level according to their being successful in learning the current lectures, they were given a four-point scale with seven-items in it. In addition to these, lastly, Approaches to Learning instrument that had 26 items was also completed by the students. The achievement of the students was measured by the percentage of course points earned for the fall semester in the English class in which the questionnaires were taken. The factor analyses were applied after the data was collected and reliability coefficient for the self-efficacy instrument was found as .91. In addition to this, the analyses of data showed zero-order correlations which provide validity evidence for the study. At the end, the results of the study again showed a direct and positive relationship between self-efficacy and academic achievment demonstrating the importance of self-efficacy for successful learning and improved understanding.

In a correlational study made by Pintrich and DeGroot (1990), motivational orientation including test anxiety, self-efficacy and intrinsic value; self-regulated learning, and classroom academic performance were examined. The sample of the study was 173 seventh graders from eight science and seven English classes. The students responded to a seven-point likert scale, self-report questionnaire called as Motivated Strategies for Learning Questionnaire (MSLQ). There were 56 items in this instrument. After data was collected, factor analysis was conducted and according to the analysis of the motivational items three obvious motivational factors were revealed: intrinsic value, self-efficacy and test anxiety. The reliability of self-efficacy scale is found as .89 with nine items under it. However, the study does not give information about the validity of the instrument. Results of the study showed that self-efficacy, student cognitive engagement and performance were positively related to each other. But when the cognitive variables were included in analyses, the relation between self-efficacy and performance on exams was not found to be significant. The reason of this result should be because of cognitive engagement variables are more directly related to academic success, so when they are involved in the studies, self-efficacy seemed like less important.

2.2.1.2 Anxiety

The fifth construct is the *anxiety* that is defined as "general uneasiness, a sense of foreboding, a feeling of tension" (Hansen, 1977, p. 91). Anxiety could be felt by everyone from time to time. Sometimes, anxiety is good in that it helps the students to be motivated. It was found to hinder students' motivation if a high level of anxiety was seen in an individual, however too little anxiety is also debilitate performance (Cassady & Johnson, 2002). For this reason, anxiety is accepted as another construct of motivation.

According to Sansgiry, Bhosle and Dutta (2005), there are two major components of test anxiety; cognition and emotion. The mental activity that is revolving around the testing incident or its potential implementations on the individual and that is constituding elements, such as thinking about failure consequences, worrying so much about the exams and having low self-confidence in one's ability is the cognitive component of anxiety and the physiological component of test anxiety that causes tension and nervousness towards exams is the the emotionality component of it.

In the literature there were different studies conducted on students' anxiety that displays the inverse proportion between anxiety level and academic success of the students that is related to students' learning. For example, the meta-analysis studies conducted by Hembree (1988) on 562 studies and Seipp (1991) on 126 studies; revealed a negative relationship between anxiety level of the students and their academic performance. There were other studies that also found the same negative correlation between anxiety and academic performance (e.g., Cassady & Johnson, 2002; Chapell, Blanding & Silverstein, 2005; Dündar, Yapıcı & Topçu, 2008; Zeidner, 1998). To give an example, Chapell, Blanding and Silverstein (2005) conducted a study with 1414 graduate students next to 4000 undergraduate students for examining whether there was a relationship between test anxiety and students' academic performance. In order to assess students' anxiety Test Anxiety Instrument (TAI) was used with a reliability coefficient of .80 and students' current cumulative GPA were collected to have an idea about students' academic performance. The results reported that high-test anxious undergraduate students score one-third letter grade lower and in terms of graduate students, it was revealed a significant inverse relation between the students' TAI scores and their cumulative GPA. In addition to these results, females consistently report higher test anxiety for both graduate and undergraduate students. This result was an expected one since anxiety causes students' to lose their motivation which consequently result low achievement. Since this study include a large sample size, it won't be wrong to make a generalization that anxiety and achievement are inversely related to each other.

To conclude, after examining each construct, it was revealed that each construct of motivation were also related to students' understanding, learning and consequently their achievement. For this reason, their effects on students' understanding, learning and achievement separately need to be taken into account during the conducted study. In addition to these, the link between students' motivation and understanding, learning or achievement needed to be studied from a general view.

2.2.1.3 Goal-Orientation

The third construct about the motivation is the *goal orientation*. If students have their own learning goals, they tend to be more motivated intrinsically, since they will be focused on learning especially, whereas if students have their own goals related to their performance tend to be more motivated extrinsically, since they focused on competition (Cavallo, Rozman, Blinkenstaff, & Walker, 2003). In other words, goal orientation is directly related to students' motivation which refers to the fact that the type of goal toward which an individual is working has a huge effect on how they follow the goal.

There are lots of goal orientation theories and all of these theories divide goal-orientation into two main labels that represent the same constructs (e.g., Dweck, 1986; Midgley, Kaplan, & Middleton, 2001; Nicholls, 1984). For this reason, it is not possible to control the effect of goal-orientation on students' achievement without its constructs. In this study, these constructs will be accepted as mastery goal orientation and performance goal orientation (as cited in Ames, 1992).

Mastery goal orientation basically focuses on learning or willing to put forth a lot of effort to master a skill or concept. For mastering the task, the individual would work very hard, insists on working even if s/he come face to face with difficulties. S/he will take risks and try things that they don't already know how to do whereas; performance goal orientation focuses on grades and demonstrating the ability. These students aim to do better than everyone else and they do not take risks. So, they prefer to be involved in the tasks that they know they could do. In performance goal orientation, the researchers recently defined two subgroups. One is the individuals that are working toward the goal of appearing competent (approach performance) and avoiding appearing incompetent (avoidance performance). According to Eliot and Harackiewiez (1996), in approach performance, individuals could be positively motivated to try to outperform whereas in avoidance performance, the individuals could be negatively motivated to try to avoid failure and seen dumb. Their goal is to play it safe and only do what they know will be successful.

According to the results collected from the studies that studied on the approach goals and avoidance goals separately, there was found to be a positive relation between college students' course achievement and their performance-approach goal orientation (Church, Elliot & Gable, 2001; Elliot & Church, 1997; Elliot & McGregor, 2001). In addition to this, when the mastery goal orientation was studied on younger students; many studies could not find a relation between the mastery goal orientation and younger students'grades (McWhaw & Abrami, 2001; Pintrich, 2000; Skaalvik, 1997). According to Schunk and Pintrich (2002), mastery goals have been shown to be positively related to academic achievement whereas the performance goals are seen to be negatively related to academic achievement. Students' adoption of mastery goals has been shown to be conductive to the use academic achievement and self-reported mastery goals also found to be positively related to academic achievement.

There are also some evidences that multiple goal orientation supports positive learning outcomes (Harackiewicz, et al., 2000; Harackiewiczet al., 2002; Mattern, 2005; Pintrich, 2000). However, there are also some studies that did not determine a difference between multiple goal orientation and single goal-orientation. For example, a study conducted by Mattern (2005) aimed to investigate whether students who had multiple goal orientation (both mastery and performance goals) scored higher than their peers who had single goal orientation (only performance goals or only mastery goals). There were 143 undergraduate students from a public university. Data was collected by the Motivation Strategies for Learning (MSLQ) instrument developed by Pintrich, Smith, Garcia, and McKeachie (1991) as a survey. Even if this instrument composed of two parts, students completed only the 8-item section of the instrument to assessed motivational orientations. For the mastery items, the internal consistency reliabilities were .77 and for the performance-approach items, the reliability was .66. The collected data was then analyzed by one-way ANOVA to determine which achievement goal group attained higher academic achievement. The results of the study revealed that the multiple goal groups and the single goal group were not different from each other statistically. However, when Tukey post-hoc analysis was applied, between the high mastery group and the high performance group, a significant difference was found that was in the favor of mastery goal group. The reason of this result may be because of selecting a wrong design since a survey research design was applied in this study. However according to the researcher of this study, this was not the best way to determine what goals college students actually hold. In addition to these, since survey was applied, the aim of the study should be representative, but in this study a small sample including only one university size was applied that cause a limitation for generalization. Also, there was no pre-test administration to evaluate students' achievement before the MSLQ administration in this study which may be another reason of this result according to the researcher of the study.

2.2.1.4 Intrinsic and Extrinsic Motivation

According to Ryan and Deci (2000), motivation could be categorized under two subtitles that are the *intrinsic* and *extrinsic motivation*. Intrinsic motivation could be defined as motivation to do something for learners' own sake and the extrinsic motivation is defined as motivation to do something for reaching a determined target (Mazlo et al., 2002). The intrinsically motivated students will study harder than the other students to achieve high grades they see these high grades are rewards for them since they especially focus on learning. These could be thought as a challenge that is done by the student intrinsically. Pintrich and Schunk (1996) argued that these challenges should be appropriate for students' level. Because, if they are too easy, students will search for more difficult ones; and if they are too difficult, then the students may abandon their efforts and their intrinsic motivation will be decreased. According to Ryan and Grolnick (1986), teachers prompt their students' intrinsic motivation, curiosity, and their desire for challenge when they are autonomy-supportive rather than controlling.

Extrinsic motivation gives student an incentive or privilege for finishing the given tasks and assignments. These students perform “in order to obtain some reward or avoid some punishment external to the activity itself. These rewards may be in the form of stickers, grades or teacher approvals” (Lumsden, 1994, p.1). Teachers sometimes provide extrinsic motivation for the students to finish a given task that are not charming for all students. But extrinsic motivation should be applied with caution since it may sometimes inhibits students’ intrinsic motivation level because students may only finish the given tasks if they are provided an extrinsic motivation and this may affect their sense of entitlement negatively in other areas of their lives (Cook, 2006).

Studies showed that when the intrinsic motivation of the students is encouraged, their academic success is increased (Adelman & Taylor, 1983; Goldberg & Cornell, 1998; Gottfried, 1985; Harter & Connell, 1984; Lepper, Corpus, & Iyengar, 2005; Lepper & Henderlong, 2000). The study made by Gottfried (1985) investigated the relationship between students’ intrinsic motivation and academic achievement. There were a total of 567 elementary and junior high school students in the study. The Academic Intrinsic Motivation (AIM) inventory instrument that was developed by the researcher was applied and the results of the study showed that AIM was significantly and positively correlated with students’ school achievement.

Jurisevic, Glazar, Razdevsek, Pucko, and Devetak (2008), conducted a study to detect the level of intrinsic motivation and extrinsic motivation of the pre-service primary school teachers’ in terms of their learning science in relation to some other subjects and the major focus of this study was on students’intrinsic motivation to learn chemistry and its correlation with students’ academic achievements in chemistry. The study conducted with 140 teachers who completed a questionnaire related to their intrinsic motivation and another test related to their knowledge about general chemistry concepts. Researchers applied the IMLS instrument since this instrument measures students’ intrinsic motivation for learning biology, chemistry, mathematics, language and studying with 125 likert scale items. The reliability of the instrument was .78 and by the help of correlation calculations, proposed multidimensional model of intrinsic motivation's validity was also confirmed. One other instrument used in this study was the "Test of Basic Chemical Knowledge" (TBCK) which was applied to determine the basic understanding of chemical concepts. This instrument included 14 chemistry problems that require understanding of chemical concepts and the reliability of this instrument was .72 and three independent experts in science and chemical education confirmed the validity of the instrument. Students were exposed to the 30-week chemistry course then both instruments were administrated in groups at the end of the chemistry course. The results of the study showed that the subjects are motivated to learn generally but level of intrinsic motivation for learning chemistry is very low whereas the level of intrinsic motivation for learning biology is very high. Results also showed a weak correlation between students' chemistry knowledge and their general intrinsic motivation for learning chemistry that is statistically significant according to the results of TBCK instrument. But, the correlation between motivation and the mark achieved in chemistry test is statistically not significant. Even if the the examination had both written and oral components in it, this study only checked the results collected by the written TBCK test. Thus, the reason of having statistically insignificant results might be because of this situation. Also, the results were under the effect of external stimuli rather than pnternal stimuli since the doing exam on students is obviously goal-oriented. Moreover, according to the results of this study, it was proved for extrinsic motivation to be negatively correlated with academic outcomes. This result should be because of students wanted to be involved in more easy work or because of their will to please their teachers by doing worse on both standardized tests and during the assessments conducted in classes.

A cross-sectional study conducted by Lepper, Corpus, and Iyengar (2005) studied on relation between intrinsic motivation, extrinsic motivation, and academic achievement on math and reading. There were 797 third-grades through eighth-grade students from two public school districts with large ethnic diversity. A questionnaire with five-point likert scale items was administered to the students by seven questionnaire administrators. The completion of the questionnaires took approximately 30 min in each classroom. Students' scores on the math and reading portions of the California Achievement Test, students' grades on report cards were collected for achievement evaluation. By the findings the intrinsic and extrinsic motivation to show significant correlations with academic achievement's two objective indices, the validity of the intrinsic and extrinsic motivation evaluations was provided for this study. Also the reliability of the test was evaluated as .90. The results of the study revealed that students that have higher academic achievement in school having fun during learning, feel the capability of being involved in challenges, and like to study the material independently only to learn the related concepts. Accordingly, it was concluded that there was a direct relationship between intrinsic motivation and students' performance on standardized tests. Because this study was a survey, its generalizability is high. But, there were some limitation in this study since there was no control over threats to internal validity. Since this study was conducted on different districts and different schools there is location and subject characteristic threats mainly. In addition to this, instrumentation threat also might be a limitation. There might also a correlation between intrinsic and extrinsic motivation which was not analyzed by the researchers.

2.2.1.5 Self-determination

The fourth construct is the *self-determination*. It is defined as the ability of an individual to have some degree of control and choices in how and what s/he does it (Deci, et al., 1991; Reeve, Hamm & Nix, 2003). The studies showed that, self-determination is related with intrinsic motivation construct. According to Deci (1996), students in particular need to feel competent and independent. In this study it was mentioned that intrinsically motivated activities support competence and independence feelings, whereas extrinsically motivated activities could weaken them. The study conducted by Deci (1996) also showed that the students who have self-determined motivation have more chance to achieve at a high level and to be emotionally well adjusted.

Accordingly, Vallerand and Guay (1995) conducted another study in order to check over a motivational model based on the theoretical framework developed by

Deci and Ryan (1985) for school performance. In order to achieve this aim, the adapted version of the Academic Motivation Scale that was translated into French next to perceived academic self-determination and perceived academic competence instruments were all administered to the students. The results revealed that autonomous academic motivation was positively influenced by students' perceived self-determination and academic competence that that in turn had a positive effect on students' school performance. This study does not include an experimental or longitudinal design and in addition to this, prior achievement or ability level has not been controlled which are important limitations.

There are different studies that revealed the indirect relation between students' achievement and self-determination (e.g., Black & Deci, 2000; Boiché, et al., 2008; Levesque, et al., 2004; Shih, 2008; Veermans & Tapola, 2004). To give an example, the study made by Shih (2008), tried to understand how self-determination, achievement goal theory and motivation are related to each other and to understand students' participation in school work. Study was conducted with 343 eighth-grade high school students. An adapted version of a self-report survey that was translated into Chinese was employed to collect data. In order to assess students' academic engagement, the scales adapted from the Rochester Assessment of Intellectual and Social Engagement (RAISE) was used. Results supported self-determination theory (SDT) that, when students learn that were not related to their personal interest, they are more fully participate in school, both emotionally and behaviorally.

According to the studies, it could be concluded that if a student is lack of self-determination, this will result having difficulty in feeling intrinsically motivated since they will begin to believe that they have no control on their own performance which will result in learned helplessness. Thus, self-determination is concluded to be an important construct for motivation of the individuals.

2.2.2 Students' Motivation and Their Understanding

Since the focus of science education researchers is increasing the level of science learning for each student, it is obvious that evaluating students' achievement is one of the common ways of evaluating students' understanding and their learning since students who understood the related concepts should have higher achievement and vice versa. For increasing the achievement, students' understanding and learning of the related concepts needed to be increased. For this reason; researchers realized the importance of affective variables, specifically the effect of motivation by identifying the relationship between students' science achievement and their science motivation.

From a general point of view, Weiner (1970) stated that, once the students become motivated, the result will be learning and learning should be evaluated from the students' achievement. The students who show high achievement will be the ones who are highly motivated because, high motivation in students triggers them to be involved in more achievement activities; improve students' intensity during studying, help them to find more power to persist when they face failure and make them choose more tasks of intermediate difficulty when compared to students who show low achievement.

Several studies indicated that motivation affects students' learning, understanding and consequently their achievement directly and indirectly (Cleary & Chen, 2009; House, 1993; Pintrich & DeGroot, 1990; Schunk & Pintrich, 2002; Tella, 2007). The study conducted by Tella (2007) was trying to investigate the motivation effect on secondary schools students' academic achievement in mathematics. The sample for this study was 450 secondary school students from ten schools in two different areas in Ibadan. The data were collected by the Motivation for Academic Performance Questionnaire (MAPQ) which was formed by the researcher. It was a five-point likert scale and its reliability coefficient was found as .85 after a pilot study. Another instrument used in this study was an achievement test in mathematics which was also constructed by the researcher to evaluate students' academic success. This instrument was found to be reliable since its reliability coefficient was found to be .82. However, the validity of the instruments was not mentioned in the study. The result of the study showed that students that are highly motivated to mathematics have higher academic achievement when compared to low motivated students. In other words, the students being highly motivated or lowly motivated differ in terms of their academic achievement in mathematics since the difference was found to be significant. This was an expected result since motivation makes students spend more effort on learning the given subject and consequently causing meaningful learning in students.

Although motivation is found to an effective indicator on students' understanding, learning which increases their achievement, there were also other studies that have found either no significant relationship or a little between motivation and academic achievement (Goldberg & Cornell, 1998; Niebuhr, 1995; Stipek & Ryan, 1997). For example, the study conducted by Niebuhr (1995) studied on the relationships between various variables that include a research for detecting the relationship of individual motivation and students' academic achievement. 241 high school students were administered a survey that has 163 items in it. The instrument used for this study was the Harter motivation instrument (Harter, Whitesell, & Kowalski, 1992) which was developed for evaluating if a student's motivation was oriented intrinsically or extrinsically. To evaluate students' achievement, grade point averages of the students were applied. The findings inferred from this study indicate that student motivation and students' academic achievement had no significant relationship (Niehbur, 1995). One reason of this result might be because of applying the grade point averages that were reported by the students since they may not be as valid as school records.

Since motivation and students' understanding, learning and achievement has a strong relationship according to the results of most of the studies, science educators also made studies on instruments to measure students' motivation. For example, both Tuan, Chin, and Shieh (2005) and Glynn and Koballa (2006) proposed instruments in order to measure students' motivation to science with reliability coefficients of .89 for former and .93 for latter. These instruments are found to be highly applicable in science area and they were used in many studies that aimed to evaluate students' motivation.

Glynn and Koballa (2006), gave importance to students' being motivated to learn science. Thus, in a report they wrote in a book chapter, they tried to explain the importance of motivation next to its different constructs. At the end of this book chapter about motivation, they introduced an instrument that measures students' motivation to learn science. It was an advice for teacher to apply this instrument since all teachers aimed to improve students' motivation and it was found to be a reliable instrument because of its high internal consistency (93%). Since this instrument was measuring students' motivation to learn science, it was named as "Science Motivation Questionnaire".

Accordingly, Glynn, Taasoobshirazi, and Brickman (2007) conducted a study in order to test a theoretical model of motivation to learn science (SMQ) on non-science majors' and the relation between students' learning and motivation of the subjects. For this reason, 369 students from a college science course in which a large-enrollment was provided to satisfy the core curriculum requirement were surveyed. The Science Motivation Questionnaire (SMQ) developed by Koballa and Glynn (2006) was applied as an instrument. Subject's average science grades were also used in order to assess students' learning. After the data collected and analyzed, interviews are done with the students in the study. Results of the study showed that students' motivation had a strong and direct influence on students' learning. Interviews with subjects of the study provided insight into their motivation. At the end of the study a model was developed which suggests instructors to relate science concepts to the careers of non-science majors in order to increase motivation and learning by developing the Science Motivation Questionnaire (SMQ) according to the results revealed by this study that provides science education researchers, science instructors and science literature an instrument that is consistent, valid and reliable next to being convenient to evaluate students' motivation to learn science and to assess the impact of instructional methods that were formed for increasing students' motivation. The authors of this study suggested including motivation and motivational constructs into account while studying on students' learning in science majors mainly.

Since motivation was found to be one of the most crucial factors that affect students understanding and learning which in turn improves students' achievement a very reliable instrument, the Science Motivation Questionnaire (SMQ) developed by Koballa and Glynn (2005), was improved into its second form as Science Motivation Questionnaire II (SMQ II) by Koballa and Glynn (2011). Since science is composed of a range of different disciplines and because motivation was accepted to be one of the major affective variables that influence students' understanding, learning and consequently their achievement, several studies were conducted in each discipline for evaluating students' motivation for improving students' understanding and learning separately. Moreover, both versions of the SMQ were used in different studies and different disciplines because of its being reliable, valid and easy to be applied. In other words, SMQ was adapted into different disciplines or translated into different languages in recent years. One of these disciplines the researchers adapted these questionnaire was chemistry which was one of the most problematic science discipline according to literature (Akgun, Gönen, & Yılmaz, 2009; Demircioğlu, Ozmen, & Ayaş, 2004; Huddle, White, & Rogers, 2000; Orgill & Sutherland, 2008; Özmen, 2004; Wickman, 2004).

To give an example, the study conducted by Çetin-Dindar & Geban (2009) adapted the science motivation questionnaire (SMQ) into Turkish and restricted it with the chemistry discipline to apply the new form on another culture (Turkish), on a different age group (university students) and with narrowing the focus of the questionnaire on only chemistry learning. At the end, the Chemistry Motivation Questionnaire (CMQ) was formed which was then applied on 669 university students from two universities in Turkey for measuring its reliability, validity and for confirming the constructs of the questionnaire. When the results of the study were analyzed, it was found that this adapted instrument had a reliability of 0.880. Moreover another study conducted by Salta and Koulougliotis (2014), adapted the version of SMQ II into chemistry and translated this questionnaire into Greek for applying this questionnaire in another culture (Greek), on a different age group (secondary school students) and with narrowing the focus of the questionnaire on only chemistry learning. Subsequently, the Greek Chemistry Motivation Questionnaire II (Greek CMQ II) was formed to examine the secondary school Greek students' motivation to learn chemistry. This adapted version was then applied on a sample of 330 secondary school students and the adapted version was also found to be applicable.

To conclude, motivation was one of the important ingredients of meaningful learning in science which consequently effects students' science achievement in a positive direction. In addition to this, chemistry was defined as one of the most difficult areas of science that is also needed to be examined deeply. Thus, the chemistry understanding, learning and achievement would be put under the scope in this study.

2.3 Chemistry Understanding and Acids and Bases Topic of Chemistry

Science has a significant role in our life. It is all around the world, environment we live in. For that reason, it is the core concept of the curriculums for students in primary and secondary school to prepare individuals to life. Research showed that, students have many misconceptions about different areas of science (Akgun, Gönen, & Yılmaz, 2009; Ghani, Hamim, & Ihsak, 2006; Gomez-Zwiep, 2008; Johnstone, 2008; Novak, 2002; Stein, Barman, & Larrabee, 2007; Thompson & Logue, 2007; Yalcin, et al., 2009). These misconceptions prevent meaningful learning, understanding and cause difficulties for solving daily life problems consequently. One of the most problematic science area is chemistry (Akgun, Gönen, & Yılmaz, 2009; Demircioğlu, Ozmen, & Ayaş, 2004; Huddle, White, & Rogers, 2000; Orgill & Sutherland, 2008; Özmen, 2004; Wickman, 2004) since chemistry includes many topics that influence daily-life. In order to be good at chemistry, it is important for a student to make connections with daily life and the concepts of chemistry. Because, each matter individuals met in daily-life have specific properties and chemistry is simply explaining these properties. But, in reality, most students have difficulties in learning and understanding chemistry. One possible reason might be starting from the beginning of this study, students' may not be building the appropriate understandings related to the fundamental concepts of chemistry (Gabel, Samuel, & Hunn, 1987). According to the study results conducted by Wood (1990), another reason might be the fact that students' success in chemistry courses is related to what they have learned in their previous courses. Other possible reasons which might make understanding the concepts related to chemistry difficult include its language that was specialized (Bergquist & Heikkinen, 1990), its nature that incline mathematics and the large amount of concepts that needed to be learned (Johnstone, 1984) and most common reason is because of chemistry's abstract conceptual nature (Carter & Brickhouse, 1989; Demircioğlu, Ozmen, & Ayaş, 2004; Lawson & Renner, 1975) since chemistry requires students to cope with several objects that could not be seen with naked eye or which could not be directly perceived, like atoms, molecules, or ions (Ward & Herron, 1980).

This variety of reasons that cause students' having difficulty in learning and understanding chemistry concepts consequently influence students' academic achievement. In other words, students' learning difficulties results low achievement in chemistry learning (e.g., King, Bellocchi, & Ritchie, 2008; Nieswandt, 2001; Ozden, 2009; Sigler & Saam, 2006, 2007). To erase these difficulties in understanding and learning chemistry, researchers applied constructivist methods of teaching in recent years.

To give an example, in the study conducted by Bektas (2011) 5E learning cycle model integrated with analogy, role playing and concept mapping was applied and compared with the traditional instruction to examine the impact of this instruction on students' understanding of the matter concepts and the results of the study revealed that the students implemented by 5E learning cycle model were more successful when compared to traditional instruction in terms of students' conceptual understanding.

Similarly, Akkuş, Kadayıfçı, Atasoy and Geban (2003) also conducted a study to determine students' misconceptions concerning chemical equilibrium topic for overcoming students' learning difficulties related to this topic and to compare the effectiveness of conceptual change instruction based on the constructivism and traditionally designed instruction on 71 tenth grade students' understanding of chemical equilibrium concepts. The study took five weeks to be conducted and the instruction was given by the same teacher to both experimental and control groups. Chemical Equilibrium Concept Test and Science Process Skill Test were applied to both experimental and control group of the study. The reliability of Chemical Equilibrium Concept Test is found to be .78 with 45 item objective test and this instrument is used as both pretest and posttest and it is .82 for Science Process Skill

Test included 36 items. The collected data was analyzed by ANCOVA in which the science process skill test scores and students' prior knowledge were used as covariate. The results of the study revealed a significant difference between the students who applied the constructivist principles-oriented instruction and the students those taught by traditionally designed instruction in terms of understanding the related to chemical equilibrium concepts. This is because constructivist based method explicitly deal with students' misconceptions while traditionally designed instruction method did not. In this study, some threats to internal validity were controlled. These are implementation, students' characteristic and location. But the other main threats like attitudes of students, testing or instrumentation were not taken into account. Also, there was no information about the effect size of the study. For this reason, although the study showed statistically significant results, it is not possible to discuss practical significance of the study.

However, there were some studies that were not supporting the findings above. For example, an action research study that was conducted by Baddock and Bucat (2008) to investigate the impact of a chemistry demonstration in which cognitive conflict strategy was applied to remedy students' difficulties. For this reason, 66 students from 11^{th} grade were chosen from three classes of a school. The students were given a demonstration about acid-base topic of chemistry in each lecture and at the end of these lectures volunteer students were interviewed. The results of the study showed that there was no effect of demonstration by using cognitive conflict strategy on students' learning. This study includes both demonstration and cognitive conflict methods that are based on constructivism. But, since this is an action research; the teachers are the implementers of the study that is a big threat to internal validity. Since there was only one school in this study, the location and history threats were controlled, however, the generalizability of the study is limited. In addition to these, it would be better to include a control group, more schools, and a post-test to collect quantitative data and control some extraneous variables to the study. So, to conclude the design of this study was not appropriate.

One of the topics in chemistry that the students have low academic achievement is the acid-base chemistry (Banerjee, 1991; Cros et al., 1986;

Demircioğlu, Ozmen, & Ayaş, 2004; Kausathana, Demerouti, & Tsaparlis, 2005; Hand et al., 1991; Nakhleh, 1994; Sheppard, 2006; Sisovic & Begovic, 2000; Watters & Watters, 2006). Many studies tried to identify the reasons and concepts which students' have difficulty in acid-base chemistry (e.g., Bilgin & Geban, 2006; Boo, 1998; Butts & Smith, 1987; Furio-Mas, Calatayud, & Barcenas, 2007; Garnett, Garnett, & Hackling, 1995; Kousathana & Tsarpalis, 2002; Orgill & Sutherland, 2008, Schmidt, 2000; Smith, 1987; Taber, 2002; Urbansky & Schock, 2000; Yılmazoğlu, 2004).

According to the literature, some studies identified the reason of the students' learning difficulties in acids and bases concepts as students having misconceptions and these studies revealed some misconceptions of the students as their evidences. To give an example, in Taber's (2002) study, on double decomposition reactions, a misconception was determined that decreases students' understanding; reactants' ions have to give the electrons to their original atoms back before a new electron transfer occurrs to form the precipitate. Another study conducted by Nakhleh and Krajcik (1994), determined that strong acids are believed to be melting metals and destroying them may cause students' to have problems in learning. In the study of Schmidt (2000), it was reported that students were thinking the reaction between magnesium oxide/hydroxide and hydrochloric acid was a redox reaction because of their oxygens in the oxide and hydroxide structures. In another study conducted by Ross & Munby (1991), it was found that all of acids are harmful which were accepted as other reasons for students' learning difficulties about acid-base concepts. According to Schmidt's (1991) study results, students believed that neutralization term was found to be acting as a hidden convincer which leads to the misconception that the neutralization product is a neutral solution and another misconception that is the pH of a salt solution resulted from neutralization is always seven (Ayas & Demircioğlu, 2002; Demircioğlu, Özmen & Ayas, 2002; Schmidt, 1991) and there are neither H^+ nor OH^- ions in a neutralization reaction between a strong acid and a strong base is also found (Ayas & Demircioğlu, 2002; Demircioğlu, Ayas, Demircioğlu, 2005; Schmidt, 1991). Garnett, Garnett, and Hackling (1995) also stated that students believed that weak acids could not act as well as strong acids; and pH could not measure basicity since it is only the measure on acidity.

Some other studies were also conducted for defining the concepts, misconceptions of acids and bases in which the students have difficulty in learning. According to Yılmazoğlu, (2004), quickly solving the calculations related to titration problems was troublesome for many students in chemistry lectures. According to the findings found by Butts and Smith (1987), students could not realize the connection between the the low solubility of the salt and the formation of the precipitate ocured with the double decomposition reaction. Moreover, the study conducted by Boo (1998) revealed that students had a misconception in terms of defining the driving force for a double decomposition reaction since they believed it was the caused by the difference in reactivity between the metallic elements present in the involved compounds**.** One other study conducted by Kausathana, Demerouti, and Tsaparlis (2005) revealed that it seems to be difficult for some students to understand the existence of OH^- in an acidic solution. In addition to these, Urbansky and Schock (2000) found that students seem to have difficulty solving buffer problems.

Demircioğlu, Ozmen, and Ayaş (2004), have conducted another study in order to investigate 150 high school students' understanding and misunderstanding of acid and base concepts. For this reason, a test with five open-ended, fourteen multiple-choice and six multiple choice with an explanation section; with a total of 25 items was developed by the researchers. The test was piloted with 40 students and its reliability of multiple choice questions of the test was found to be .81. The results of the study revealed some misconceptions of the students. Many of the determined misconceptions were identified in the literature before; like students' beliefs of strong acids to melt metals and destroy them (Nakhleh & Krajcik, 1994), students' finding all acids to be harmful (Demircioğlu, Özmen, Ayas, 2004; Ross & Munby, 1991), the pH of a salt solution resulted from neutralization is always 7 (Ayas & Demircioğlu, 2002; Demircioğlu, Özmen & Ayas, 2002; Schmidt, 1991) and there are neither H^+ nor OH^- ions in a neutralization reaction between a strong acid and a strong base (Ayas & Demircioğlu, 2002; Schmidt, 1991). What is important in this study is, there is an important contribution of this study to related literature since a new misconception is determined which is students' misconception about "all bases to be harmful and poisonous" (p.5). What is not mentioned in the study was how long the study took, how the test was administered and the reliability coefficient for the open-ended questions. In addition to this the validity of the test was not given which was an important issue to be given in the study.

The study conducted by Kausathana, Demerouti, and Tsaparlis (2005) aimed to explore instructional misconceptions in acid base equilibrium from the history and philosophy of science perspective. For this reason, 119 twelfth grade students were participated in the study. A written questionnaire that has two forms was constructed to the students. Each form of the test consisted of ten multiple-choice and nine open-type questions. The reliability of the questionnaire was calculated by Cronbach alpha coefficient, as .63 for the multiple-choice type questions, and as .78 for the open questions. Results of the study analysis showed that the students were more familiar with the Arrhenius model, although they were taught the Brønsted–Lowry model in the twelfth grade. Also, it seems to be difficult for a number of students to realize the existence of OH^- in an acidic solution (Kausathana, Demerouti, and Tsaparlis, 2005). In addition to these, students usually learn that the strong acid determines the pH, so only the acid ionization is taken into account for determining the pH value. The significance of this study is that, this study emphasizes the importance of textbooks and searching the history and philosophy of chemistry in order to facilitate students' understanding. What is not given in the study is the validity of the test, effect size and also the way how the test was prepared. In addition to this, threats to internal validity were not mentioned in this study that might cause limitation. In this study main threats that could be seen in this study are attitudes of participants, implementation, location, subject characteristic and instrumentation.

Since the students' misconceptions were defined as an important source of students' learning difficulties, it was also important to identify the cause of these misconceptions formed in students' minds. An important cause of students' misconceptions is identified as students being unable to explain chemical concept at the macroscopic, microscopic, and symbolic levels (Raviolo, 2001). Lacking the necessary conceptual background is also another reason of students' difficulties in learning acids and bases chemistry (Watters & Watters, 2006). Another specific reason that students have difficulty in learning acid-base chapter is because of not selecting an effective teaching method. Some other reasons of the misconceptions are; students not being able to visualize chemical events as dynamic interactions spontaneously, students come for instruction having an everyday meaning to the words that also have scientific meaning (Nakleh, 1992) or students being involved in complex activities that require conceptual understanding (Yılmazoğlu, 2004).

To conclude, teachers should avoid memorization while teaching chemistry, apply more real-life situations to make the abstract as concrete as possible and try to develop conceptual understanding in students which should be possible by including constructivist teaching methods into teaching so that students' learning difficulties caused by misconceptions should be remedied.

2.4 Misconceptions in Acids and Bases Concepts

After the realization of importance of misconceptions in students' understanding and learning, several researchers conducted different studies to identify students' misconceptions on several subjects of science. Thus, there were many different studies administered on acids and bases concepts and many different misconceptions were identified. The misconceptions found in the literature on acids and bases concepts are given as a summary:

- All acids and bases are harmful and poisonous (Demircioğlu, Ayas & Demircioğlu, 2005)
- Bases have only OH ions but not H ions (Canpolat, et al., 2004; Demircioğlu et al., 2005; Demircioğlu, 2010; Hand & Treagust, 1991; Morgil et al., 2002; Nakhleh & Krajcik, 1994; Ozmen & Demircioğlu, 2002)
- Bases turn blue litmus paper red, and acids turns red litmus paper blue (Demircioğlu et al., 2005; Demircioğlu, 2010; Hand & Treagust, 1991; Morgil et al., 2002; Nakhleh & Krajcik, 1994; Ozmen & Demircioğlu, 2002)
- Acids burn and melt everything (Demircioğlu et al., 2005; Demircioğlu, 2010; Hand & Treagust, 1991; Morgil et al., 2002; Nakhleh & Krajcik, 1994; Ozmen & Demircioğlu, 2002)

- Acids melt metals (Nakhleh & Krajcik, 1994)
- An acid can burn you (Hand & Treagust, 1991)
- Fruits are basic (Çetingül & Geban, 2011)
- Testing of an acid can only be done by trying to eat something away (Hand & Treagust, 1991)
- Acids are stronger and more dangerous than bases (Ross & Munby, 1991; Sheppard, 2006)
- An acid is something which eats material away (Hand & Treagust, 1991)
- Acids and bases show opposite properties of each other (Çetingül & Geban, 2011)
- The bases that include only one OH group can be ionized completely (Demircioğlu et al., 2012)
- The condition to be an acid of a substance is its having H atom in the structure (Yalçın, 2011)
- All substances that include H atom is acid (Yalçın, 2011)
- Acidic solutions do not include OH ions and basic solutions do not include H ions (Canpolat et al., 2004).
- The pH is inversely related to harm and bases are not harmful (Nakhleh & Krajcik, 1994)
- As pH increases, acids become harmless and bases are not harmful (Demircioğlu, Ayas & Demircioğlu, 2005)
- Concentration is a measure of acid or base strength (Canpolat et al., 2004)
- Concentrated base solution is stronger than diluted one (Yalçın, 2011)
- A strong acid can eat material away faster than a weak acid (Hand & Treagust, 1991)
- A strong acid is always a concentrated acid (Demircioğlu, Ayas & Demircioğlu, 2005)
- Acids are strong and bases are not strong (Nakhleh & Krajcik, 1994)
- Strong acids are sourer and burn more than weak acids (Bradley & Mosimege, 1998; Çetingül & Geban, 2011; Demircioğlu et al., 2005; Demircioğlu, 2010; Hand & Treagust, 1991; Metin, 2011; Schmidt, 1991; Nakhleh & Krajcik, 1994)

- Strong bases contain more OH ions than weak bases and strong acids contain more H ions than weak acids (Bradley & Mosimege, 1998; Çetingül & Geban, 2011; Demircioğlu et al., 2005; Demircioğlu, 2010; Demircioğlu, et al.; 2012; Hand & Treagust, 1991; Metin, 2011; Schmidt, 1991; Nakhleh & Krajcik, 1994)
- Strong acids and bases are not ionized completely in their solutions because of the strong bonding between them (Demircioğlu et al., 2012)
- Strong acids do not easily react / weak acids do not easily react (Bradley & Mosimege, 1998; Çetingül & Geban, 2011; Demircioğlu et al., 2005; Demircioğlu, 2010; Hand & Treagust, 1991; Metin, 2011; Schmidt, 1991; Nakhleh & Krajcik, 1994)
- Weak acids are ionized more easily (Demircioğlu et al., 2012)
- When a weak acid and strong bases are mixed at equal volume and concentrations, since acid is weak, neutralization will not completely occur (Yalçın, 2011)
- There were not any OH^- ions in the solution of weak acids (Yalçın, 2011).
- As a weak acid is diluted, because its acidity constant will be reduced, the percentage of ionization also decreases (Yalçın, 2011)
- As a weak acid is diluted, its ionization percentage is reduced (Yalçın, 2011)
- As a weak acid is diluted, its percentage of ionization is decreases, dilution of weak acid ionization cause no change in its ionization percentage (Yalçın, 2011)
- As a weak acid is diluted, since its dissociation constant will be reduced, so the percentage of ionization decreases (Yalçın, 2011)
- The pOH of weak bases and the pH of weak acid is between 0 and 7 (Metin, 2011)
- The pOH of strong bases and The pH of strong acid is between 7 and 14 (Metin, 2011)
- In equilibrium, the bases that have small Kb value are less concentrated (Demircioğlu et al., 2012)
- While a strong acid has strong bonding among molecules, a weak acid has weak bonds among molecules (Metin, 2011)

- Strong bases do not conduct electricity (Metin, 2011)
- While strong bases have strong bonds among molecules, weak bases have weak bonds among molecules (Metin, 2011)
- When a strong acid is added to a weak base, an acidic solution is formed (Çökelez, 2010)
- When a strong base is mixed with a weak acid, the solution will be basic (Tuan & Feng, 2005)
- When a weak acid and strong base solution at equal volume and concentrations are mixed, a neutral solution will appear (Yalçın, 2011)
- Neutralization of acid and base always gives a neutral product (Pınarbaşı, 2007; Tuan & Feng, 2005)
- Acids and bases neutralize only if they are in equal concentrations (Yalçın, 2011)
- In neutralization all the H and OH ions are cancelled (Horton, 2007; Demircioğlu, Ayas, & Demircioğlu, 2005)
- In a neutralization reaction, when one of the reactants (acid or base) is weak, the neutralization does not completely take place (Pınarbaşı, 2007)
- Acid and bases give neutralization reaction only if their concentrations are equal to each other (Yalçın, 2011)
- Neutralization of acid and base always gives a neutral product (Schmidt, 1991)
- Every neutralization yields a neutral solution (Schmidt, 1991)
- Acid and base consumes each other completely in all neutralizations (Schmidt, 1991)
- Any reaction between an acid and a base a neutral solution is formed (Schmidt, 1997)
- Conjugate acid-base pairs consist of positively and negatively charged ions, which can somehow neutralize each other (Schmidt, 1997)
- When an acid and a base are mixed, no reaction occurs; instead a physical mixture was formed (Canpolat et al., 2004).

- When HCl and NaOH are mixed, regarless of their initial volume and concentration, the number of OH^- ions are equal to the number of H^+ ions in the formed solution (Çökelez, 2010).
- To neutralize is to break down an acid or to change from an acid; a base is something which makes up an acid (Hand & Treagust, 1991)
- In all neutralization reactions, acid and base consume each other completely (Demircioğlu, Ayas & Demircioğlu, 2005)
- At the end of all neutralization reactions, there are neither H^+ nor OH^- ions in the resulting solutions (Demircioğlu, Ayas & Demircioğlu, 2005)
- In a neutral solution, there are not any H^+ or OH^- ions (Çökelez, 2010)
- If indicators are not used in titrations, no reaction occurs (Canpolat et al., 2004)
- Indicators help with neutralization (Demircioğlu, Ayas & Demircioğlu, 2005)
- Indicators are used as a measure of acid strength (Çetingül & Geban, 2011)
- Indicators are used to provide the neutralization in acid base reactions (Çetingül & Geban, 2011)
- The equivalance point and the endpoint are the same thing (Canpolat, et al., 2004)
- If one of the acids and bases are weak in a titration, the neutralization does not occur completely (Canpolat, et al., 2004)
- It is impossible to make a solution with a pH = 0 (Morgil, et. al, 2002)
- pH is a measure of acidity and pOH is a measure of basicity (Canpolat et al., 2004; Demircioğlu et al., 2005; Demircioğlu et al., 2002; Hand & Treagust, 1991; Köseoğlu et al., 2002; Metin, 2011; Morgil et al., 2002; Ross & Munby, 1991)
- As the value of pH increases, acidity increases and as the value of pOH increases, basicity increases (Demircioğlu et al., 2005; Demircioğlu et al., 2002; Hand & Treagust, 1991; Köseoğlu et al., 2002; Metin, 2011; Morgil et al., 2002; Ross & Munby, 1991)
- As the number of hydrogen atoms increases in the formula of an acid, its acidity becomes stronger (Demircioğlu, Ayas & Demircioğlu, 2005)
- All salts are neutral (Demircioğlu, Ayas & Demircioğlu, 2005)
- Salts don’t have a pH value (Demircioğlu, Ayas & Demircioğlu, 2005)

- Salt consists of a reaction between strong acid and strong bases which react again to acids or bases (Metin, 2011)
- Salt consists of a reaction between strong acid and strong bases react again to strong acids or bases (Metin, 2011)
- Neutral salts react with acids and bases (Metin, 2011)
- Salt consists of a reaction between strong acid and weak bases. But it doesn’t react again to weak base (Metin, 2011)
- Salt consists of a reaction between strong acid and weak base. This salt is a neutral salt (Metin, 2011)

According to the literature, it can be concluded that students even if students’ ideas were not showing parallelism with science, they have some ideas about acids and bases concepts. The specific reasons of students having misconceptions were defined as finding chemistry abstract, complex or difficult to understand. The summary of students’ misconceptions revealed that students’ have more ideas about acids when compared to bases (Çetin-Dindar, 2010). Moreover, the misconceptions can mainly be collected under specific headings: definition of acids and bases, strength of acids and bases, pH/pOH, neutralization reactions, indicators and salts. In this study some misconceptions from the literature were used to develop the acids and bases concept test (ABT) and the cases used in this study.

Since students have many different misconceptions on acid-base topic of chemistry, in recent years, several methods, strategies and approaches of learning/teaching acid-base topic of chemistry were also introduced to determine and overcome students’ misconceptions and increase their understanding (e.g., King, Bellocchi, & Ritchie, 2008; Nieswandt, 2001; Ozden, 2009; Sigler & Saam, 2006, 2007). Many of the studies conducted to determine and overcome students’ misconceptions related to acids and bases concepts are based on constructivist teaching methods since; its effect on meaningful learning could not be ignored.

For example, Demircioğlu, Ayaş and Demircioğlu (2005) conducted another study to examine the impact of a new teaching material on students’ achievement and misconceptions for acids and bases concepts. The conceptual conflict strategy based on constructivism was applied in the development of the new material which imncludes worksheets. The sample size was 88 students from a high school. The teachers were trained before the instruction to control implementation threat to internal validity. The Concept Achievement Test (CAT) that was developed by the researchers of the study, including 20 multiple choice questions related to acids and bases were administered to the students in both control and experimental group as both pretest and posttest. This test was used to identify students' misconceptions and its internal reliability was found as .92. In addition to this test, Chemistry Attitude Scale (CAS), that included 25 attitude statements, was also developed and applied to the students as both pretest and posttest. Its reliability coefficient was .84 and validated by three professors in the field of education. After the instruction, interview was done with 10 students; students were separated according to their grades they got from their previous exams in chemistry as being high achievers, middle achievers, and low achievers. The results of the study showed that there was a significant difference in chemistry achievement between the experimental group and the control group; however, a few students maintained their misconceptions. The reason of this result might be because of the lack of active participation in acquiring of knowledge which was mainly suggested by constructivism. Even if this study was designed appropriately, some important threats to internal validity were not controlled and the data analysis method was not appropriate for this study. The researchers applied t-test analysis in their study. But, there are extraneous factors that might affect the study results. For example, attitude of the treatments was not controlled. That is an important limitation of this study since it might explain the result of significant statistical results of this study by its own. Also, even if pretest was applied, its results were not used to control subject characteristics threat to internal validity. So, application of ANCOVA might be more appropriate. In addition to these, no effect size or power of the study results were not provided that is also a limitation for this study.

To conclude, the literature review gives an insight about the positive effects of constructivism based teaching methods on students' understanding, their academic achievement, learning and motivation on acids and bases concepts. But, there are some limitations that these studies did not take into account. For this reason, there is a need for another study that might fill these gaps. Under the light of the findings from the literature, a constructivist method, case based learning (CBL) that was found to be effective on motivating students to learn chemistry, increase students' meaningful learning, and understanding that also increase their achievement was applied in this study. In the literature, CBL is mostly used in medical science and biology education and there are few studies made on chemistry with CBL specifically. For chemistry, acid-base topic is still seems to include many misconceptions in students that were not be overcome. By CBL, it is aimed for students to make this topic more meaningful so that they might be able to see the relation of chemistry and real life that motivate them to learn acids and bases concepts which might help them to overcome their misconceptions consequently and improve their understanding that leads to increased achievement. To conclude, this study will include CBL for improving students' understanding of acids and bases concepts and their motivation to learn chemistry.

2.5 Summary of Previous Study Findings

It is possible to summarize the results of the previous studies as follows:

1. Constructivist methods are more popular and appropriate to increase students' learning in chemistry.
2. Different constructivist methods that applied to acid-base topic of chemistry have some contributions to chemistry but none of them could also achieve to teach acids and bases concepts through real-life events or interesting cases and overcome students' misconceptions to learn chemistry at the same time.
3. Case based learning show positive effects on improving students' understanding, their critical thinking and social skills; and on their higher order thinking skills.
4. Case based learning show positive effects on overcoming students' misconceptions.
5. Motivation is an essential factor that affects students' understanding that leads to improved achievement in students.

6. Each motivational construct should be taken into account while studying on improving students' understanding.
7. Students mostly have difficulty in learning chemistry and one of the most difficult topics was Acids and Bases.
8. Acid-base topic of chemistry seems to include many misconceptions in students that couldn't be totally remedied by different teaching methods.
9. Many of the constructivist studies did not mention the power or the effect size related to their studies.
10. Many of the constructivist studies did not mention the reliability or the validity of their instruments they used in their studies.
11. Many studies did not consider the threats to internal validity. The most common threats are subject characteristic, instrumentation and attitudes of the participants.

These summary suggest that there is a need for research to (a) develop a new method to increase students' understanding of acids and bases concepts and motivation to learn chemistry by suggestions of previous studies for meaningful learning (b) take the most common motivational constructs into account while increasing students' understanding on acids and bases concepts (c) try to remedy students' misconceptions related to acids and bases concepts to improve students' understanding (d) test the effectiveness of treatments while controlling threats to internal validity. This study aimed to accomplish these goals.

CHAPTER 3

DESIGN OF THE STUDY

In this chapter, population and sample, instruments, data collection and analysis, development of the an instruction based on case based learning and traditionally designed instruction, treatment, treatment verification, power analysis, internal validity, limitations and assumptions of the study are explained briefly.

3.1 Population and Sample

Target population of the study will be all 11^{th} grade high school students in Karabük and Ankara. As it is not feasible to reach all eleventh grade high school students in Karabük and Ankara, as accessible population all eleventh grade students in 100.Yıl district of Karabük and Çankaya district of Ankara were selected. Karabük is in the northwest of Turkey that is also close to the middle part. Karabük's population is mainly composed of officers, engineers and workmen because of the Demir-Çelik factory that is the heart of Karabük's source of living and this population is mainly from middle social class. Ankara is in the middle part of Turkey. Ankara's population is again mainly composed of officers, engineers and workmen since Ankara is the capital city of Turkey. To briefly explain, being the capital city makes Ankara the center of many areas especially policy. So, the population is mainly from high-middle social class because of political reasons. In Turkey, after the first year of the high school, at the beginning of 10^{th} grade, students choose classes that they will continue such as science and mathematics weighted classes or social courses weighted classes. In this study, students were chosen from 11^{th} grade science and mathematics weighted classes as their classes included more chemistry classes and they have a background in chemistry.

There are 511773 high school students in Ankara and 21538 high school students in Karabük (MEB, 2013). There are 354884 students in general types of high schools in Ankara and 14855 students in general types of high schools in

Karabük. Also there are 156889 students in other types of schools of Ankara (vocational school, industrial school, technical high school, etc.) and 6683 students in other types of schools of Karabük. The sample was selected by convenience sampling. 100. Yıl school districts in Karabük and Çankaya school districts in Ankara were chosen as many of the high schools were placed in these districts and they should be more representative for that reason. There are 102 high schools in Çankaya, Ankara and twelve high schools in 100.Yıl, Karabük. There is also one private school in Merkez and one in 100.Yıl. According to Cohen's (1977) sample size table, for a power of 0.8, with large effect size, for alpha to be 0.05 the needed sample size was estimated as 26 students per condition which means per group for this study. Since there were two groups in this study, a total of 52 students should be appropriate for conducting the study.

According to the information from Karabük MEB (2014) and Ankara MEB (2014), assuming each class to include approximately 40 students, it was evaluated to apply the study on at least 160 students. Considering that there might be some problems in schools, classes or subjects; this study was applied to four experimental groups and four control groups from two schools with one of which has two experimental and two control groups each. So, at the end, it was calculated as 320 students except the students in the pilot study to be involved in this study when the effect size and power analysis were considered.

There were two general high schools chosen –one Anatolian High school from Ankara and one science high school from Karabük- instead of vocational schools, Anatolian teacher high schools or technical high schools. The reason for choosing these schools was firstly because of their convenience. Secondly, because of the characteristics of both schools' students were similar according to their academic achievement since they entered these schools by entering an exam and getting closer grades. Thirdly, the students in both schools showed interest in the area of science and mathematics together since in Turkey, the students were separated according to their interests in courses.

In Karabük, 11th grade classes in the selected school were all included to the study and they were chosen randomly to be involved in the study as the experimental or control group. In other words, each method was randomly assigned to the each class. In Ankara, the same selection was done since again the selected school classes were all included to the study. However, the assignment of the classes to be control or experimental was not randomly assigned for all classes which will be explained below. The school selected from Ankara is one of the best schools of Turkey since generally all the students of the school come with high degrees to the school, get high grades during their teaching in this school and pass the university exam with high degrees as they were graduating from there. In addition to that, the school selected from Karabük is also one of the best schools in Turkey because of the same reasons. In addition to these, even if Karabük is in the northwest of Turkey, it is close middle part of Turkey and the structure of the employees are very similar to Ankara, it could be accepted for both cities to mainly have equal social backgrounds mainly which was taken into consideration since the researcher wanted the schools to be equal as much as possible compared to their achievements to overcome the problems that may result because of the initial social or cultural differences.

There were four chemistry teachers included in this study. Three of them were from the Anatolian High school in Ankara and one of them was from the science high school. The reason of having one teacher for four classes in science high school was because of the teacher's being separated according to the grade levels. There were four chemistry teachers in this school and all teachers were assigned to one grade. Thus, only one teacher was teaching to the eleventh grade students. This was a good opportunity for this study since by having only one teacher entering all control and experimental classes prevents teacher characteristics to be a threat to this study until she obeyed the lesson plans as much as possible. Also, random assignment of the groups for all classes was easily done for science high school. However, in the Anatolian school, there were three teachers who taught in eleventh grades. Two of the teachers were male and they were at the same ages. They both were working for this school more than ten years and both of them were working in "dershane" next to giving private lessons in their homes for more than fifteen years. The other teacher was female and younger than these two teachers. However, she was working for this school again more than ten years. Thus, it can be concluded that, they became to show similar characteristics after spending many years together. All three teachers were also writing a book all together and getting on very well with each other. Thus, their characteristics were accepted to be similar to each other accordingly. The female teacher had two classes one of which was randomly assigned to be experimental group and the other one to be the control group. For the other two teachers, a random assignment was done to decide the class to be the experimental or control group. Then, one of these two teachers was trained for the study next to the teacher who had two classes already in this study.

Names of schools, teachers and students were not given in this study because of ethical reasons. In the school selected from Çankaya, Ankara; two classes were thought with an instruction based on CBL and the other two classes were thought with traditionally designed instruction. Again, in the school selected from 100.Yıl, Karabük; two classes were thought with an instruction based on CBL and the other classes were thought with traditionally designed instruction. Each school had an equal chance to be assigned in the study. Internal validity threat due to attitude of subjects was tried to be remedied as the instruction based on CBL was began one week earlier than acid-base chapter (with rate and equilibrium in reactions chapter) and applied to all students in the study. By this application, the students in the experimental group became familiar with the method which was expected to prevent the Hawthorne effect and also the control group selected was also became familiar with the treatment and did not demoralized so much as they were treated in a different way.

Moreover, in Anatolian High school, there were two hours for chemistry lectures in each week. In addition to these, the chemistry teachers had one chemistry application lecture hour in each week. Thus, there were three lecture hours in each week to implement this study. For science high school, there were four lecture hours in each week directly. However, the study had to be prepared by taking number of Anatolian high school lecture hours since they were less than science high school lecture hours for the experimental group. In other words, there was one lecture hour left for science high school students in which the teacher was trying to give free time to her students as much as possible for equalizing the experimental groups of both schools.

3.1.1 Sampling

In this study, the sample mentioned above was formed by convenience sampling. The reason for choosing convenience sampling was because no random sampling could be applicable in the study because of studying on the intact groups. Also, cluster sampling was not be applicable because, if the schools were selected as clusters, then the used clusters needed to be selected randomly according to cluster sampling rule and all the students in the school should be used in the study. Simple random sampling also was not applicable since there were many 11th grade students in 100. Yıl districts of Karabük, Turkey and Çankaya district of Ankara, Turkey which was impossible to determine each subject.

The districts that the tests were applied were chosen as 100.Yıl which was located in the Karabük city of Turkey and Çankaya which was located in the Ankara city of Turkey which were easy to reach for the researcher. Two schools were chosen according to their availability for the study. These schools included a total of four control and four experimental groups separately. In order to decide the classes that would be involved in the study as control or experimental groups, they were chosen randomly since there were four 11th grade classes in science and math major in both schools. In the school selected from Ankara, there were three teachers and four 11th grade classes that include a total of 146 students in the school (73 students in the control groups and 73 students in the experimental groups) and each teacher had at least one class. For this reason, one of the teachers had two classes. In this situation, for the teacher with two classes, one of the classes of her was randomly assigned to be the control group and the other as the experimental group and for the other two teachers, their classes and their selves were thought as one. So, one of their classes was assigned randomly, so that his class was automatically be the experimental group and the others' be the control group. In the school from Karabük, there were four 11th grade classes with again 142 students (71 students in the control groups and 71 students in the experimental groups) and they were all taught by the same teacher.

So, two classes of this teacher were selected randomly to be included in the study and assigned to be the experimental groups and the others were assigned randomly to be the control groups of the study. These procedures were followed since the researcher wanted both control groups and experimental groups to be taught by the same teacher as much as possible. So the implementer threat for internal validity would be controlled as much as possible. By this way, a total of 288, 11th grade students were included in the study.

In addition to these students, the pilot study that was conducted on twelve 12^{th} grade students (eight students from the same Anatolian high school which took a part in this study and four students from the same science high school which took a part in this study) a semester before the real study conducted. The data was collected by the researcher in both schools. But two of the students from science high school did not complete the pilot study so that they were excluded.

To conclude, even if it was planned to include 320 students in this study, in reality, this study was conducted on 298 students since there were approximately 35, 36 or 37 students in the classes of the selected schools and there were 10 students from the pilot study of the tests were also added to the study. Moreover, even if the data were collected from 298 students, there were 292 valid data collected from the students of this study because of the missing data.

3.2 Variables

According to Frankel and Wallen (2006), experimental research is the most powerful research for testing the relationship between variables and this research is more likely to result with the clear-cut interpretations. Experimental studies include at least two types of variables; independent variable and dependent variable. Independent variables could be manipulated and have effect on other variables. Dependent variables could not be manipulated and they could change with the change in independent variables. Since this study was a quasi-experimental research study, there were two types of variables in this study too.

3.2.1 Independent Variables

In this study, there were eight independent variables at the beginning. These were; the treatment (group) used with two levels which were the traditionally designed instruction method (TDIM) and the instruction based on case based learning (CBL), the school types with two levels: Anatolian high school (AHS) and science high school (SHS), pre-test scores of students on Acids and Bases Chemistry Test (pre-ABT), pre-test scores of students' self-efficacy construct of the Chemistry Motivation Questionnaire (pre-SE), pre-test scores of students' anxiety construct of the Chemistry Motivation Questionnaire (pre-ANX), pre-test scores of students' goal orientation construct of the Chemistry Motivation Questionnaire (pre-GO), pre-test scores of students' intrinsic motivation construct of the Chemistry Motivation Questionnaire (pre-IM) and pre-test scores of student self-determination construct of the Chemistry Motivation Questionnaire (pre-SD). Table 3.1 showed the detailed characteristics of the independent variables used in the present study:

Table 3.1 The characteristics of the independent variables in the study

Variable Name	Variable	Continuous/Categorical	Scale
Group	Independent	Categorical	Nominal
School	Independent	Categorical	Nominal
Pre-ABT	Independent	Continuous	Interval
Pre-SE	Independent	Continuous	Interval
Pre-ANX	Independent	Continuous	Interval
Pre-GO	Independent	Continuous	Interval
Pre-IM	Independent	Continuous	Interval
Pre-SD	Independent	Continuous	Interval

However some of these independent variables were assigned to be covariates because of several reasons mentioned in Chapter 4. In the next part, these covariates were introduced.

3.2.1.1 Covariates

According to the study needs, some of these independent variables were used as covariates. These were; pre-test scores of students on Acids and Bases Test (pre-ABT), pre-test scores of students' self-efficacy construct of the Chemistry Motivation Questionnaire (pre-SE), pre-test scores of students' anxiety construct of the Chemistry Motivation Questionnaire (pre-ANX), pre-test scores of students' goal orientation construct of the Chemistry Motivation Questionnaire (pre-GO), pre-test scores of students' intrinsic motivation construct of the Chemistry Motivation Questionnaire (pre-IM) and pre-test scores of student self-determination construct of the Chemistry Motivation Questionnaire (pre-SD). Table 3.2 showed the detailed characteristics of the covariates used in the present study:

Table 3.2 The characteristics of the covariates in the study

Variable Name	Variable	Continuous/Categorical	Scale
Pre-ABT	Covariate	Continuous	Interval
Pre-SE	Covariate	Continuous	Interval
Pre-ANX	Covariate	Continuous	Interval
Pre-GO	Covariate	Continuous	Interval
Pre-IM	Covariate	Continuous	Interval
Pre-SD	Covariate	Continuous	Interval

3.2.2 Dependent Variables

The dependent variables in this study were the 11th grade students' post-test scores of students on Acids and Bases Chemistry Test (post-ABT), post-test scores of students' self-efficacy construct of motivation from Chemistry Motivation Questionnaire (post-SE), post-test scores of students' anxiety construct of motivation from Chemistry Motivation Questionnaire (post-ANX), post-test scores of students' goal-orientation construct of motivation from Chemistry Motivation Questionnaire (post-GO), post-test scores of students' intrinsic motivation construct of motivation from Chemistry Motivation Questionnaire (post-IM) and post-test scores of students' self-determination construct of motivation from Chemistry Motivation Questionnaire (post-SD). Table 3.3 was given to show the detailed characteristics of the independent variables used in the present study:

Table 3.3 The characteristics of the dependent variables in the study

Variable Name	Variable	Continuous/Categorical	Scale
Post-ABT	Dependent	Continuous	Interval
Post-SE	Dependent	Continuous	Interval
Post-ANX	Dependent	Continuous	Interval
Post-GO	Dependent	Continuous	Interval
Post-IM	Dependent	Continuous	Interval
Post-SD	Dependent	Continuous	Interval

3.3 Instruments

For this study two instruments were used to gather data. These were Acid-Base Test (ABT) that was developed by the researcher and the adapted version of the Science Motivation Questionnaire (CMQ) which was translated into Turkish and restricted with chemistry then named as chemistry motivation questionnaire (CMQ) by Çetin-Dindar and Geban (2009):

3.3.1 Acid–Base Test (ABT)

This instrument was developed by the researcher in the first semester of 2014 to determine students' understanding of acids and bases concepts. It was a multiple choice test that included 33 questions in it. As expected from the multiple choice tests, there was only one correct answer to each question and four distracters. The language of the test was Turkish, because chemistry course was instructed in Turkish by the teachers.

The questions in ABT were created with the inspiration from the text books and according to the teachers’ thoughts and experiences mentioned in the meetings conducted before the study with teachers of the schools the study was conducted in. The curriculum was reviewed during the creation of this test for choosing its content. Since the items were selected related to the content from the curriculum, they all were related to the acid-base concept. During construction of items, care was taken to eliminate any extraneous factors that might prevent the students to find the correct answer. In addition to these, the items in the test were chosen according to the instructional objectives and were designed in such a manner that each of them examines students’ knowledge of acids and bases concept.

Moreover, while choosing the test items and questions, the misconceptions of the students that were found in the literature (see Demircioğlu, Özmen, Ayas, 2004; Morgil et al., 2002; Nakhleh & Krajcik, 1994; Ross & Munby, 1991; Schmidt, 1991; etc.) were also taken into account. In addition to these, after having conversations with the teachers of both schools about students’ difficulties and misconceptions; some misconceptions were also formed and included into the ABT test that were parallel to the misconceptions in the related literature. The reason of forming some misconceptions under the light of the misconceptions in the literature (e.g Çetingül & Geban, 2011; Nakhleh & Krajcik, 1994; Ozmen & Demircioğlu, 2002; Yalçın, 2011), in the textbooks (e.g. Atalay, 2011; Atasoy, 2004; Barke, Hazari & Yitbarek, 2009; Dursun et al., 2012; Gallagher & Ingram, 2001; Hill, Kolb & McCreary, 2009; Kaya, 2012; Kind, 2004) and from the teachers’ experiences was; for revealing if students had new or undetermined misconceptions, learning difficulties related to the concepts of the acids and bases, and also because of having some concepts that were not analyzed in terms of misconceptions in a detailed way.

At the beginning, the ABT had 35 items in it and these items were analyzed by three experts in science education and chemistry for the appropriateness of the items, for the construct validity evidence, for representativeness of the acids and bases concepts and for checking the wording/spelling of it. After getting the experts’ opinion, the test was revised by the researcher and some of the items of the test were corrected whereas some of them were distracted. At the end, there were 33 questions in the ABT that were all accepted to measure students' understanding of acids and bases concepts.

After that, three students who were the freshman in a university were given the ABT with blanks spaces left after each questions and they were announced that they might feel free to write any comments such as the grammatical errors or the unclearity of each item to these blanks. Then they were asked to measure the time the test takes to be completed and note it. The reason for taking students opinions was for checking the face validity of the ABT and the reason for asking students to record the time the test takes was for deciding on the appropriate time for completing the test and if necessary, excluding some questions. Based on the students' feedbacks the questionnaire was revised once again and its final version was formed (see Appendix C).

The pilot study was conducted a semester before the real study on twelve 12^{th} grade students, eight of whom were from the same Anatolian High school in Ankara and the four of whom were from the same science high school in Karabük. However, only ten of these students gave valid data to be used in this study since the two students in the science high school did not complete the treatment. Even if there were only 10 students for pilot study to be conducted, the reliability of the test was checked by Cronbach alpha and it was found as 0.72 which may be accepted as moderately high power and applicable.

Since this study included the acids and bases concepts, it was important to include the most appropriate test to assess students' understanding. This test seemed to include similar OSS questions which would take students' attention during administration. In addition, as mentioned above, some misconceptions of the students were taken into account that were important to be determined and remedied since one of the advantages of Case based Learning (CBL) is overcoming students' misconceptions. So, it was possible to check if students' misconceptions were remedied or not, by the help of treatment. Below, the Table 3.4 shows the misconceptions in the ABT instrument and the number of the questions they were in:

Table 3.4 Misconceptions in the ABT

Misconceptions	Question #
Acids turn litmus paper to purple (Cros et al., 1986; Cros et al., 1988; Demircioğlu et al., 2005; Hand & Treagust, 1991; Morgil et al., 2002; Nakhleh & Krajcik, 1994; Ozmen & Demircioğlu, 2002).	1
Bases turn litmus paper to red (Cros et al., 1986; Cros et al., 1988; Demircioğlu et al., 2005; Hand & Treagust, 1991; Morgil et al., 2002; Nakhleh & Krajcik, 1994; Ozmen & Demircioğlu, 2002).	1
The strength of acid is directly proportional with the increase in the number of hydrogen in their formula (Çetingül & Geban, 2011).	2
For a material to be basic, there must be OH^- in its structure (Yalçın, 2011).	3
All acids and bases are harmful and poisonous (Demircioğlu, Özmen, Ayas, 2004; Ross & Munby, 1991)	3
Acids and bases destroy the metals that were thrown into them (Nakhleh and Krajcik (1994)..	3
Acids and bases only give neutralization reactions when their concentrations were equal (Yalçın, 2011).	3
There was no OH^- ions in the aqueous solution of a weak acid (Kausathana, Demerouti, and Tsaparlis, 2005)	6
The solutions that include H^+ are all acids (Yalçın, 2011).	6
A strong acid is always a concentrated acid (Demircioğlu, Ayas, Demircioğlu, 2005).	6
When a strong acid and a strong base give neutralization reaction, the pH of the formed solution is always 7 (Ayas & Demircioğlu, 2002; Demircioğlu, Özmen & Ayas, 2002; Schmidt, 1991).	6
It could not be mentioned about the effect of acid or base in the taste of fruits (Demirci & Özmen, 2012).	7
Acids are harmless. For this reason, the acid rains don't give harm to historical artifacts (Demirci & Özmen, 2012).	7
In the combustion events, carbon (C) and hydrogen gas (H_2) give reaction with water (H_2O) and turn into acidic form (Morgil et al., 2002).	7
Any of the materials that include acid could not be eaten or drunk (Demirci & Özmen, 2012).	7

Table 3.4 Misconceptions in the ABT (continued)

Misconceptions	Question #
The increase in pOH results in the increase in the strength of a base (Metin, 2011).	9
pH is only a measure of acidity (Demircioğlu, Ayas, Demircioğlu, 2005; Garnett, 1995; Metin, 2011).	9
If pH > pOH then; $[H^+] > 1x\ 10^{-7}$ M (Morgil et al., 2002).	10
If $[H^+] > [OH^-]$ then; pH > 7 (Morgil et al., 2002).	10
Cations could easily take protons and show base properties (Seçken, 2010).	13
*The salt solutions that include the conjugate bases of weak acids have higher hydrogen concentration	13
The cations that form the structure of the strong bases show acidic properties (Seçken, 2010).	14
*It was enough to check the strength of the bonds in order to find the halogen acids' strength.	16
*The $[H_3O^+]$ ion' concentration is equal to the weak acid's ion concentration that forms the solution.	19
It is impossible to prepare a solution with a pH of 0 (Kariper, 2011; Morgil et al., 2002).	24
*Stippling O_2 that was formed after metabolical events is one of the missions of the buffer solutions.	28
When acids and bases are equal in concentration and volume, the solution would be neutral (Yalçın, 2011).	30
The neutralization could not occur completely in the reaction between strong acid and weak base (Pınarbaşı, 2007).	30
When a strong acid reacts with a weak base, the solution formed becomes neutral (Yalçın, 2011).	30
Since the citrate is a stronger acid when compared to lime, it could dissolve the lime at the bottom of water boiler (Demirci & Özmen, 2012).	33
Both lime and citrate were acids. Since only an acid could dissolve another, citrate could dissolve the lime at the bottom of the water boiler (Demirci & Özmen, 2012).	33

*: This misconception was formed by the researcher for the present study.

There were some other questions that were also controlling if students had any misconceptions related to acids and bases concepts. However, they were asked in the correct form instead of being asked as a misconception as some of these questions also included the corrected forms of misconceptions. To give an example, in the literature, there was a misconception as “As a weak acid is diluted, its percentage of ionization decreases” (Yalçın, 2011). However, this was not used as an alternative to the study; instead its corrected form was asked as an alternative: “As a weak acid is concentrated, its percentage of ionization decreases”. Thus, if a student had misconception, then their answer would again be wrong (see questions 11, 12, 15, 18, 20, 24, 26, 27 and 29). The other questions that were not in the table were designed for improving students’ mathematical problem solving skills which was also important to improve because of the university entrance exam (see questions 4, 5, 8, 17, 21, 22, 23, 25, 31 and 32).

To conclude, for developing the ABT test, the objectives of the acid-base chapter in Turkish curriculum (see Ortaöğretim kimya dersi öğretim programı, 2014), the misconceptions related to acids and bases concepts in the literature, the textbooks and the teachers’ experiences were used since this study aimed to apply the objectives of acids and bases test to overlap with the whole concepts about acids and bases and also determine students’ misconceptions to be remedied. Because of these reasons, ABT is found to be an appropriate instrument that could be used in this study.

3.3.2 Chemistry Motivation Questionnaire (CMQ)

The original Science Motivation Questionnaire (SMQ) was developed by the Koballa and Glynn (2006) to determine students’ motivation to science. It includes 30 items that assesses six components of motivation: intrinsically motivated science learning, extrinsically motivated science learning, relevance of learning science to personal goals, responsibility (self-determination) for learning science, confidence (self-efficacy) in learning science, and anxiety about science assessment. It is a 5 point likert scale ranging from 1 (never) to 5 (always). The statements were scaled from 1 to 5 and for the anxiety about science, since it includes negative statements;

they were scaled from 5 to 1. Thus, the maximum score that could be gathered from the test was 150 and the minimum score was 30. The preliminary findings indicated SMQ as a reliable instrument with a reliability of 0.93 (Glynn and Koballa, 2006) which was very high.

According to Glynn, Taasoobshirazi, and Brickman (2007), a significant correlation, $r = 0.56$, between motivation and science GPA was found, indicated that higher motivation was related to a higher science GPA. This correlation provides additional evidence of the validity of the SMQ as a measure of motivation. To provide evidence of the reliability of the SMQ, in terms of the internal consistency of its 30 items, a Cronbach coefficient alpha was computed, and it was again found to be relatively high ($\alpha = 0.93$).

In another study conducted by Glynn, Taasoobshirazi, and Brickman (2009), study included 770 non-science subjects to examine they enrolled in a core-curriculum science course, conceptualized their motivation to learn science. The results of the study showed that the reliability (internal consistency) of this test was 0.91, which was considered to be very high (George & Mallery, 2000). The students' total scores on the 30 items correlated significantly with their reported high school preparation in science ($r = 0.58$, $p<0.001$), college science GPA ($r = 0.61$, $p<0.001$), and the relevance of science to their careers ($r = 0.50$, $p<0.001$), providing evidence of criterion-related validity.

In this study, the adapted version of science motivation questionnaire (CMQ) into Turkish and restricted with chemistry discipline of science which was translated by Çetin-Dindar & Geban (2009) was used since not all high school students know English. At first, the test was translated into Turkish and restricted with chemistry discipline by Çetin-Dindar in 2008 and three experts revised the translated version. After the improvements, the questionnaire translated into English by two other experts to determine if there were any ambiguities in the items. After the corrections, the test was distributed to 27 students and asked them to write their comments on each question for checking the face validity of the questionnaire. Lastly, the final form of the test which was named as chemistry motivation questionnaire (CMQ) was distributed to 1612 high school students and the items of the CMQ were analyzed with principal components analysis (PCA) to determine the main constructs of the test. According to the results, there were five constructs of the test labeled as *self-efficacy in learning chemistry* (eight items: 3, 12, 21, 24, 26, 28, 29, 30), *anxiety about chemistry assessment* (five items: 4, 6, 13, 14, 18), *relevance of learning science to personal goals* (seven items: 2, 10, 11, 17, 19, 23, 25), *intrinsically motivated chemistry learning* (five items: 1, 16, 20, 22, 27), and *self-determination for learning chemistry* (five items: 5, 7, 8, 9, 15) respectively.

The reliability coefficient of CMQ was estimated by Cronbach's alpha and found as 0.902, indicating high internal consistency. For this reason, it could be said that the interpretation of the questionnaire is consistent with the real version of SMQ and even if one component of the original SMQ was distracted from this instrument, other five components were still consistent which were theoretically and statistically justified (see Appendix D).

For presenting evidence to construct related validity, another the study conducted by Çetin-Dindar (2010) in which one of the aims was improving students' motivation by making students involved in a 5E teaching strategy based instruction on acids and bases concepts. A Cronbach coefficient alpha was computed on its 30 items. It was found as 0.873 for the pre-CMQ and 0.905 for post-CMQ. Thus, it can be concluded that, CMQ was also a reliable instrument.

The reason of selecting the chemistry motivation questionnaire (CMQ) is because of its high reliability in the studies conducted by using this instrument and for its original version to be an accepted, reliable, valid and consistent instrument by all science areas. Moreover, SMQ was translated into many different languages which show its effectiveness on measuring what it supposed to measure and as being the adapted version of SMQ, CMQ also showed enough evidence about its validity, reliability, consistency and its effectiveness.

3.4 Procedures

The study starts with determining of key words based on the topic. A keyword list prepared and the research has done based on these keywords. Keywords used in this study are "case based learning", "case based instruction", "case aided instruction", "chemistry", "understanding", "chemistry understanding", " motivation", "chemistry motivation", "acid-base", "understanding of acids and bases" and "acid base concepts". The keywords were searched at Dissertation Abstracts International, Education Research Complete, Educational Resources Information Center (ERIC), Journal Storage (JSTOR), IS Web of Science, Science Direct, Social Science Citation Index (SSCI), Springer Link, Web of Science and Google scholar. METU library and ULAKBIM also searched for related journals, thesis and books that are in written formats.

In experimental research, independent variables could be manipulated and the effect of independent variable on dependent variable could be observed (Frankel & Wallen, 2006). In this study, the effect of an instruction based on case based learning and traditionally designed instruction will be compared. For this reason, the instruction based on case based learning was planned and administered to the students. In other words, some manipulations on independent variables were done. Thus, the best and appropriate research method to apply is the experimental research. In this study a type of experimental research which is called quasi-experimental design will be used as the research method. This design is used since it's not possible to make random assignment of the subjects of the study.

3.5 Threats to Internal Validity

Quasi experimental designs do not include random assignment but there are some techniques to control some internal validity threats (Fraenkel & Wallen, 2006) even if these designs could not control all of them. For example, history, maturation or testing threats may interfere with the effects of the treatment in this type of designs. In this study, non-equivalent pretest-posttest control group design is used. Because this design attempts to limit threats to internal validity, it is a type of quasi-experimental research design (Gravetter, 2006). It is identical to pretest-posttest control group design, with the exception of randomization. The groups are generally chosen from clustered units such as classrooms but the choice of clustered units that receives the experimental treatment should be made randomly (Gravetter, 2006).

Mortality will not be a threat to internal validity as missing data calculations were used for this study. Data collector bias was another threat since the study was conducted in more than one school. So; the treatments couldn't be done by the same teacher. But by preparing detailed lesson plans and educating teacher, this threat was controlled by the researcher. Also the lessons were observed by the researcher as much as possible in order to be sure that the treatments were correctly applied. Maturation threat was also controlled directly since the subjects of the study were selected from the same grade.

In order to evaluate the effectiveness of the instructions, and the change in students' motivation pre-test were applied to both experimental and control groups. This implementation could cause the testing threat to occur. This threat should arise when students remember the correct answers or they may be conditioned to know that they are being tested. For this reason, in order to control this threat, sufficient time was given between pre-tests and post-tests for desensitization. In order to control implementation threat, researcher did not be the administrators of the treatments. Instead, the cases were applied by the teachers at both schools. Also, the teachers (implementers) were trained and evaluated before the administrations begin so that their own characteristics and teaching strategies were tried to be controlled as much as possible to lower the implementer threat. In addition to this, during the analysis of the collected data, treatment verification techniques were applied to control this threat.

Attitude of the subjects threat is another important threat to internal validity since, the subjects in the experimental group may think that they are important for the researcher, or the subjects in the control group might be demoralized since they are not chosen to be in the experimental group, they also might feel there is an unfair selection so they might do better. In order to control this threat, the experimental groups began the treatment one week before the real unit to be studied and this week's case was also applied to the control groups of the study too. By this way, the treatment was tried to be made a part of regular routine and less novel for both control group and experimental group (remedying the novelty effect at the same time). In addition to this advantage of beginning the treatment with the previous chapter, by making the treatment familiar to the students, the effect of treatment was measured in a more healthy way since; students might feel excited about the new treatment and did better independent from the treatment or they might be confused about the treatment that they could not understand what was being done so that they might perform worse again independent from treatment. So, using the treatment for the first time in the study's subject prevented the evaluation of the treatment effect. History threat might be a problem since this study was not conducted in only one school or city. So, an unexpected, external event that occurs in one school could not be observed in another school. In order to control this threat, the researcher tried to observe as many classes as possible and document these unexpected, external events as small notes. Location threat was also a problem in this study because, there were more than one school in the study which means, there were different classroom environments which might cause location threat. Since it was impossible to give all the treatments in the same location, the design was tried to be applied properly; details and the locations in which the treatments were administered were checked by taking some notes to consider.

The non-equivalent pretest-posttest control group design includes intact groups of subjects. This reduces the reactive effects of the experimental procedure and, therefore, improves the external validity of the design (Dimitrov & Rumrill, 2003). The extraneous (confounding) variables that might cause problems may be the time of the classes, day of the classes, students' gender, teachers' gender, teachers' age, and size of the classes. In order to control the effect of time of the classes and day of classes, the researcher tried to adjust the time and day of the classes to be approximately the same.

In the school selected from Ankara, there were two hours for chemistry course for 11th grades and the teachers of this school were also taking another courses hour to teach chemistry again. So, there were three hours in a week for a chemistry course in 11^{th} grade (TTKB, 2013). In Karabük, there were four hours of chemistry course since this school is a science high school. The acid-base chemistry unit took thirty class hours. This means the treatment was last in ten weeks or two and a half months for the Anatolian High school where as it last in seven and a half weeks. The lessons were taught by the teachers of the schools. There were four teachers in this study. Three of whom were in the Anatolian High school and one of whom was from the science high school. However, in order to lower the implementer effect, before the treatments teachers were trained. The training schedule was prepared by the researcher of the study.

To conclude, even if it was not possible to overcome all threats with 100% success, many of the internal validity threats tried to be controlled in this study.

Furthermore, in the study, since the treatment was applied on chemistry discipline of science, students' motivation to learn chemistry was taught to affect students' learning and understanding that leads to affect students' achievement. Thus motivation to learn chemistry should also be controlled. For this reason, a test to evaluate students' motivation to learn chemistry was also given to the students who were in both experimental and control groups before and after instructions. In addition to this, as mentioned before, a test on acids and bases concepts (ABT) was applied on this unit before and after instruction to both of the groups. Table 3.5 shows the design of the study:

Table 3.5 Research design of the study

Groups	Pre-Test	Treatment	Post-Test
CG	ABT CMQ	TDIM	ABT CMQ
EG	ABT CMQ	CBL	ABT CMQ

In Table 3.2, EG represents the experimental group instructed by Case based Learning instruction through teacher lectures. CG represents the control group instructed by traditionally designed instruction method. ABT represents the Acid-Base Test, CMQ represents the adapted version of the science motivation questionnaire, TDIM represents the Traditionally Designed Instruction Method and CBL represents the instruction based on Case based Learning.

As mentioned above, the Acid-Base Test (ABT) and Chemistry Motivation Questionnaire (CMQ) instruments were administered to the students before and after treatment to determine the effect of treatment on the dependent variables and to control students' previous learning in acid-base chemistry concepts and their motivation. In other words, in order to examine the effect of students' motivation to learn chemistry on students' understanding of acids and bases concepts and to determine the change in students' motivation to learn chemistry after the treatment, CMQ was given to the students, both in experimental and control group. And in order to assess students' understanding of acids and bases concepts, ABT was applied on this unit before and after instruction to both groups. They were given to the students as pre-tests for checking their prior level of understanding the related concepts and their motivation. Then, to the control group, the acids and bases concepts were taught by Traditionally Designed Instruction Method (TDIM) whereas the same topic was thought to the students in the experimental group by the Case based Learning (CBL) instruction. After the treatment, the post-tests of CMQ and ABT were given for comparing the results of the methods.

In this study, the general aim was to compare the effectiveness of two treatments in terms of students' understanding of acids and bases concepts and their motivation. In order to control the threats to internal validity, this method was the most appropriate one. Because when these threats were not controlled, then it would be impossible to make conclusions about the effect of treatments. For this reason, non-equivalent pretest- posttest control group design which has the most control over internal validity threats was chosen for this study.

3.6 Observation Checklist & Notes

Observation checklist was formed by the researcher mainly for being sure about the treatment verification in the study. For preparing the checklist, the researcher examined previous researches about CBL instruction (e.g., Gurcay, 2003; Serin, 2009) and the already formed checklists related to these researches. After the detailed examination it was decided to give attention two main aspects during preparing the observation checklist: students' and teachers' role. Even if teachers' and students' role are very crucial during this checklist development process, it was realized that the instruction should also be taken into account with its main aspects since these roles should also show consistency with the content of the treatment and its aims. Another thing taken into account was making the checklist as clear, accurate and short as possible. So that, with one item, an insight according to the lecture should be a gained.

After these decisions, the observation checklist was developed. It included 15 items that were covering the main properties, aims and objectives of both treatments; case based learning and traditionally designed instruction next to students' and teachers' role. It was also as a five point likert scale with the alternatives excellent, above average, average, below average and poor. There was also one more alternative that is for the situations that were not observed during the lectures: not applicable (see Appendix F).

According to the checklist the observers needed to mark one of the alternatives if they think about an item to occur during the lecture hour, whereas if the observer thinks an item not to occur during the lecture hour, then, s/he needed to check the not applicable option.

All implementation sections were observed by the researcher and for the Anatolian high school; there was another observer with the researcher. So, more reliable results for the instructions were collected. There were totally 183 classroom observations coded by the researcher; a total of 107 observations from the Anatolian high school, 53 of which were in experimental group and 54 of which were in the control group and a total of 76 observations from the science high school, 39 of which were in the experimental group and 37 of which were in the control group.

When possible, during filling the observation checklists for each lecture, the researcher also tried to take notes about the lectures' progress as much as possible. Here is a part taken from a random observation from one of the lectures for the first case:

"At this point, the teacher wanted each group to make brainstorming and try to find the similarities and the differences between acids &bases unit and the karate kids. The students seemed to be having fun while reading the case. They sometimes talk to each other with a smile on their faces and ask each other what they understood from the cases. Then the teacher asked all groups to present their answers to the questions behind the case and their reasoning behind these opinions when possible. There were many students that raised their hands and very willing to share their groups' answers with the rest of the class. There is a bit noise in the class now. It seems all students were motivated. There were different results the students wanted to add to other groups' answers and the teacher tried to direct the students for discussing their opinions with each other as wanted. During the discussion, the teacher is not giving any clue to the students and did not share her comments with them. Now the teacher caught a misconception about the strength of acids and bases and asked the students about the misconceptions related to this case for a while to make the students do brainstorming. When the students were trying to explain their answers about the related misconceptions, some students seemed a bit confused. The class stopped talking and discussing for a while and tried to find the logical explanations for their thoughts when they all could not answer the reasoning behind some misconceptions the teacher asked. But the teacher did not directly give the answer to her question. Instead she showed his different science books that covers the properties of acids and bases and she wanted her students to explore these books to see if there is anything that might help them or if there is anything they forgot to add to their answers to the questions behind the case. Then the teacher wanted the students to make some generalizations when possible. Now, the teachers saw that students in one of the groups were having trouble, so she went near them and tried to guide them to find where to look for the properties in the book. There are still some students that did not understand the explanation behind some misconceptions. But now the teacher stopped directing students' explanations and wanted the students to make researches on these misconceptions after school and they would talk about them in the last lecture of this week. The teacher then wanted the students to answer another question in the given paper that asked for another property that was not mentioned in the scenario but in the science book she distributed to the students. The same procedure again followed by the teacher and at the end, she summarized the general properties of acids and bases."

According to the researchers' notes, all other scenarios mainly followed the same procedures and the teachers seemed to obey the lesson plans as much as possible. Moreover, these notes were also used during coding the observation checklists.

3.7 Reflection Papers

Reflection paper was formed by the researcher mainly for getting written feedbacks from the students so that they could be used to improve the study for the next time and to get feedback about the lectures as much as possible. It was also another evidence for treatment fidelity with one difference; they were collected from the subjects of the study about the content of each week (each case) instead of experts who make observations in the lectures. For preparing the reflection paper, the researcher examined previous researches that included this kind of materials (e.g. Gurcay, 2003; Serin, 2009). After a detailed examination, it was decided to give attention two main aspects: the positive and negative aspects of the lecture hours (cases) according to the students' view. In addition to these aspects; since students don't like to answer many questions, these paper needed to be as short and clear as possible (see Appendix E).

So, the reflection paper that asked the students about what they learned, what they realized, what they expected, what they think is lack with two questions after each week. By this way, the researcher took feedbacks not only by observing or inferring from the discussions but also a written source was collected from the students about each case formed for this study. They were also coded by the researcher for deeper analysis and for improving the study.

3.8 Treatments in Control and Experimental Groups (CBL and TDIM)

In this part, the implementation processes of the study in both groups were explained one by one.

3.8.1 General Overview and Instructional Materials for Control Groups

In the control group, the teacher applied the traditionally designed instruction method (TDIM) to teach acids and bases concepts. During the instruction in the control groups, the teachers followed their usual ways in which they were directly giving the related scientific concepts to the students by writing them on the boards or asking their students to write down what they say about the related concepts in their notebooks. The teachers only gave homework from test books when they believed it was necessary. All teachers instructed traditionally. It was a teacher-centered learning environment for many times that the teacher was explaining and teaching. Most of the time their students were passive, not allowed talking or discussing their opinions with each other or with class. Instead, they were only allowed to listen their teachers and take notes. There weren't any activities conducted for attracting students' attention during the study most of the time but the teachers might sometimes asked their students some questions that could be answered by applying mathematical skills when they taught their students were not listening to the lecture. In addition to this, their students might ask some questions about the related concepts to their teachers and the teacher gives the related answers. They were actually being memorizing the teachers' words away from really learning them or they were just writing down what the teacher writes on the board.

Moreover, the students in the control group were introduced the misconceptions related to acids and bases concepts of the day. However, these misconceptions were introduced to the students directly by their teacher when the appropriate time to introduce the related misconception was came for each concept. The teacher does not make an inquiry based questioning on students to detect their misconceptions but, if a student asked a misconception related to the acids and bases concepts, the teacher directly explained the correct form of these misconceptions.

However, one week before beginning to the implementation, the case about chemical equilibrium topic of chemistry was also applied to the students in the control group next to experimental group. It was implemented the same way as the experimental group so that the students in the control group also became familiar to the CBL learning. During its implementation in the control group, first of all the students were asked to form groups with four people in each in terms of their will without checking their grades from the last year. After the groups were formed, the students were distributed the related case about a part of chemical equilibrium. The students were asked to read the case and discuss the questions at the end of this case with their group mates to find a mutual answer to each question. After that their teachers asked them to share their answers with all class and tried to bring all students to a common answer to each question. Thus, the teachers had to manage the class discussions for some questions. In the second lecture hour, after the questions were all answered by each class, the teachers gave some specific explanations to the related concepts when necessary. Before finishing the lesson, the teachers asked their students as many questions as possible to get feedback about the related misconceptions about chemical equilibrium concepts and tried to overcome them by acting as a facilitator most of the time and letting the students refute each other’s misconceptions. At the end of the lecture teachers made a summary with their classes and it was the only application of CBL in the control groups of this study.

During the implementation, the students in the control group were not given any of the cases used in the experimental group; on the other hand, students followed their teachers during the class hours and solved more algorithmic problems. Thus, the concepts used in this study were implemented in the control group by using mainly lecturing method of teaching and sometimes questioning methods instead of inquiry based cases, collaboratively working of students in groups, class discussion. Therefore, the same concepts were taught in both groups with different procedures.

In the control groups, each concept related to acids and bases were firstly introduced by the teachers to the students. Then the teachers directly asked their students to write down what they wrote on the board. After the students wrote what was written on the board, the teachers then sometimes asked the students to answer a question related to the given concept. As the students raised their hands, the teachers select one of the students to solve the related question on the board and they moved to some difficult questions related to the concepts till the end of the lecture hours. This procedure was similar in each lecture hour of traditionally designed instruction method (TDIM) that was applied in the control groups of this study.

3.8.2 General Overview and Instructional Materials for Experimental Groups

The experimental group was thought by an instruction based on case based learning (CBL). In the lecture hours, the students were free to talk, share their opinions etc. and the teacher tried to attract their attention to the main points when the students needed help. The students work in groups collaboratively and the environment is student-centered as much as possible where the teacher acts as a facilitator or sometimes a guide during class hours.

At the end of the previous chapter, the researcher joined the experimental group classes with a case about this chapter which was equilibrium and the students were informed about the treatment and the way they would be taught by the instructor before the real first lecture of the treatment.

To administer case based learning, before the first class hour begin, the teachers of the study made the students form groups of four people which were heterogeneous according to their previous year chemistry grades according to researchers' notes and every class hour, the students form the same groups at the beginning of each lecture. Since there were three hours in a week for Anatolian high school (two real chemistry hours and one selective course that the teachers are using to teach chemistry) students met their group mates three times in a week. For science high school there were four hours of chemistry so that students met their group mates four times a week.

At the beginning of each class hour, the students were distributed some papers that include imaginary scenarios, a case, in which there are one or more characters in trouble, an imaginary story that includes some analogy for abstract concepts, an informative chapter or a real life event from a book, magazine, etc. and some related questions after the text. These scenarios are mainly realistic that have a chance to happen in real life or that are really from the real life themselves or they have some analogy included in them for making the abstract concepts related to acids and bases be more understandable. The teacher (as a facilitator and/or a guide) wanted the students to read the given cases carefully, and then find a way for solving the problem of the character(s) and consequently, solving the real life problem or answering the related questions at the end. For this reason, each group discussed their ideas with each other and all group members wrote their answers on their own papers since every student in the class were distributed the paper with the scenario on it. At this point, the students made brainstorming about this scenario by themselves. After allowing students some time, the teachers asked each student about their opinions. Students gave their answers while the teacher did not direct their answers or did not interrupt their words. Then the students were asked to discuss their solutions or answers with their classmates in order to clarify their prior concepts and reach to a general conclusion. In this process, the students would arrange their thoughts and form themes that came out from the discussion and the questions corresponding to the learning needs of the class. At the end of the discussion of all class, teacher would give the correct answer with reasons of each question under the scenario or when there could be more than one answer, try to summarize these answers by relating them to the students' answers.

In this study, the cases were developed by taking students' needs and interests into account as much as possible and each case was formed carefully so that none of the cases favor any group, characteristic or gender of students. In addition to these, since the literature showed the students had difficulty in understanding some of the acids and bases concepts because of their abstract nature or because of the different theories which were used to explain the acids and bases, some analogies were applied in some cases for teaching these subjects. The cases based on the analogies might help students to connect their prior knowledge with the new knowledge more easily (Yalçınkaya et al., 2012) and improve students' understanding about the related concepts.

Furthermore, in this study there was one case developed for students about chemical equilibrium unit and eleven scenarios (one of them is prepared for usage if time is left, however no time was left to apply the last case) for the students about acids and bases unit. The first case was formed related to the previous chapter (See Appendix G) to make the teachers practice on implementation of CBL instructions and to make the students familiar with the new teaching method so that the "attitude of the subjects" threat should also be remedied. This case was applied before the real implementation began. So; with the second case, the study actually began.

Moreover, the cases developed included some misconceptions related to acids and bases concepts. The students were analyzed whether they held any of the related misconceptions found in the literature. In addition to these misconceptions, the students were also introduced some new misconceptions in some cases which were formed under the light of the related literature and the teachers' experiences who took part in this study. The main reason of introducing these misconceptions in the cases was because of testing whether CBL instruction had a positive effect on remedying students' misconceptions if the students had some as the literature said. Also, since misconception were preventing students from learning and understanding the related concepts better; the most appropriate way to overcome these misconceptions needed to be found. Thus, CBL would also be tested whether it was a better teaching strategy to overcome students' misconceptions or not.

These cases were also designed by taking some other purposes and objectives of science teaching into account which were growing scientifically literate people for the future, improving students' creativity or higher order thinking skills next to students' social skills and teaching students about science to have a holistic structure. Thus, the formed cases included interdisciplinary teaching and nature of science aspect when they were applicable during teaching. In other words, the cases of this study had some additional aims that were not measured by instruments directly: firstly, some of the cases were designed by including one of the "Nature of Science" (NOS) aspects. The reason of including nature of science in this study was because of its being crucial for a high school student to learn the correct point of view into science. Even if there was no test developed to measure the aspects taught in some cases or no follow up interviews were conducted in this study, this study gave importance to grow scientifically literate people of the future. Thus, some of the aspects were given in the cases and the researcher's notes were used to gather feedback about the effect of NOS aspects on students. Secondly, since CBL was found to be an effective way to improve students' creativity (Garvey et al., 2000; Thistlethwaite et al., 2012), critical thinking (Alvarez, 1990; Uluyol & Güyer, 2014; Yoo & Park, 2014), higher order thinking (Herried, 1994; Tarkın, 2014) and social skills (Yalçınkaya, 2010) according to the literature; the cases tried to be formed by taking these aspects into account as much as possible and again, the researchers' notes were apllied to gather information about their effect on students. Thirdly, the cases also tried to be developed by taking the interdisciplinary teaching into account as much as possible since interdisciplinary instruction facilitate meaningful learning (Jacobs, 1989; Wood, 1997). Actually, when students' have critical thinking, higher order thinking skills and creativity, they could transfer the knowledge to other disciplines more easily (Uluyol & Güyer, 2014). Thus, the second aim was also affecting the third aim of the study. However, the other disciplines tried to be embedded in the cases to ease this transfer. Thus, some cases also included biology and physics disciplines in them. When the students realize that science has a holistic structure that was made of different areas like biology, physics, chemistry, etc. and they could not be separated, they might more easily understand the links between each discipline of science with each other.

To conclude, the cases were formed by considering to detect and to overcome students' misconceptions, to teach nature of science (NOS) aspects, to improve students' creativity, critical thinking, higher order thinking and social skills and to make interdisciplinary teaching as much as possible. In the subsections the details of these instructional materials (cases) are given.

3.8.2.0 Old Friends

This was the first case distributed to students which is not a part of the real study and applied to the experimental group students' by the researcher. The case was developed according to the inspiration from the chapter about chemical equilibrium written by Bishop (2010). Because of the limited time, only one activity related to chemical equilibrium was applied on the students. It was designed for overcoming the "attitude of the subjects" threat as much as possible; make the students become familiar with the treatment and as an example lecture for the teachers of the experimental classes.

3.8.2.1 Karate Kids

It was to make an introduction to the acid-base chapter which included an imaginary, attracted scenario that was about the general properties of acids and bases to make the students remember their old knowledge about acids and bases since they had seen this unit in the 8th grade. In this scenario, analogy was used to create the case. There were two characters that do karate and they show some properties that could make the students match with acids and bases.

After the scenario, there were five questions asked to the students. The first question asks the students to make the connections between these two characters and the general properties of acids and bases according to the scenario. The second question was designed for making a discussion environment and linkage to the next case. In this question it is mainly asked for the reason of developing a new theory about acids and bases but it is not a direct question, instead it is asked in an analogical way. The reason of putting this question here was making one of the "nature of science" aspects realized by the students; science is a developing and changing process. So, after the questions were answers, it was asked the teachers to ask students if they think science is a changing, developing process or not. The third question was asking if the students' remember the strong/weak acids and bases from the 8^{th} grade. In the fourth question the students asked to remember the acids and bases they knew and the fifth question tried to make the third and fourth questions connected to each other by making the students differentiate the strong/weak acids/and bases.

3.8.2.2 Acids and Bases in Our Daily Life

In this case, since acids and bases in our everyday life types of questions were very common and boring for the students, in this case the students did not questioned about their knowledge about acids and bases in their daily life. Instead, the main aim of this case was to detect students' misconceptions, helping the students' gain another view about acids and bases from their everyday life and raise students' awareness of the chemically produced acids and bases to peoples' health. For this reason, they were given a list of acids and bases which were naturally found inside the foods and they were given another list that includes the same acids and bases which were created chemically and inserted into our foods.

At the end of the scenario, there were related questions. The first question was asking the students if all acids were harmful (Demircioğlu, Özmen & Ayas, 2004; Ross & Munby, 1991), if they could all be eaten (Demirci & Özmen, 2012) or every fruit or vegetable are acids or bases (Demirci & Özmen, 2012). The second question was asking the same questions but this time about bases. These two questions were asked since there were some related misconceptions in the literature. The third question was asking if all acids or bases could be categorized as they are being harmful to our health. This question was also included since there were some related misconceptions in the literature (see Demircioğlu, Özmen & Ayas, 2004; Ross & Munby, 1991) but also raise students' awareness about importance of our health. The first three questions were asked as open-ended questions so that students could discuss their taught. The fourth question was asking about the misconceptions in the literature that were not directly found in the case but the case leads the students to answer the questions with rational thinking. This question was a true/false question with an additional option of "I don't know". So that when a student could not made the connection between the given case and the misconception, they could check this option and the researcher should get a feedback accordingly. The fifth question designed to help students' improve their higher order thinking skills. It was asking if the students could make an explanation about the reason of how some fruits and vegetables could make our blood acidic even if they did not have acid inside their structure or how they could make our blood basic if they did not have base inside their structure. For this question, a list of vegetables and fruits were given as a list and what they include their structure and the result of the bloods' state after the related fruit/vegetable was eaten. The aim of asking this question next to improving higher order thinking skills were increasing their critical thinking, make an interdisciplinary connection with biology, creating cognitive conflict in students and teaching the fruits and vegetables that include acid/base in their structure unconsciously.

3.8.2.3 Magical Mask

In this case, a fantastic game and its rules were introduced to the students. It was an analogy that the students connect with the Bronsted-Lowry acids and bases. The reason of applying a fantastic story, a game's rules and analogy together for Bronsted-Lowry theory was because the students still have difficulty in differentiating them according to the literature (Schmidt, 1995) and that would be more attractive for the students if there was a fantastic event behind the case. In addition to these, by the help of analogy based story, it was taught to be more effective for students to understand and differentiate this concept from others. Thus, the aim of this case was to make the students learn the Bronsted-Lowry acids and bases and differentiate them from other theories. Next to the fantastic story, the given case included a "background knowledge" part that explains the three acid-base theories according to the curriculum briefly.

After the scenario, there were three questions. The first question was asking the students to think themselves as a player of the game then, change the game into a chemical equation n their minds and write a simple chemical equation with the given variables according to the game. The aim of this question was transferring students' attention to the game into chemical knowledge without talking about Bronsted-Lowry acids and bases so that they would just put the given variables into a simple chemical equation. The second question was asking the similarities and differences between the characters of the fantastic game. In this question again there was not any explanation about Bronsted-Lowry theory so that the students should answer the question according to the case directly. The aim of the second questions was making students realize the similarities/differences between Bronsted- Lowry acids and bases unconsciously. The third question was asking for students to choose one of the theories given in the "background knowledge" that is the most similar one to the story explained in the given case. The first two questions were designed for making the students prepared for learning Bronsted-Lowry acids and bases. Actually, the third question helps the students make the connections with the Bronsted-Lowry acids and bases. When the students could transfer what they read in the case into a chemical equation and when they could see the similarities/differences between the characters of the case, they should easily understand the case was most similar to the Bronsted-Lowry’s theory and meaningful learning should occur.

3.8.2.4 Purification of Water

As it could easily be understood from its name, this case was designed for teaching the auto-ionization of water, amphoteric acids and bases, pH and pOH concepts. In addition to that, one of the topics that the students had many misconceptions according to the literature (Seçken, 2010) was anion basicity/cation acidity which is a part of salts produced by the reactions of acids and bases. So, this case also aimed to teach these concepts through their interaction with water. Also, the students had difficulties in learning the water hardness (Childs & Sheehan, 2009) concept. So, another aim of the study was teaching the water hardness by the help of this case. The case was about a factory that gave importance to the extinction of water supplies in the world so that they build a water treatment plant into the factory. After the building process, the plant was tested if it works properly or not and it was seen that some values are different from the standard values which were given in a table. For this reason it was expected from the students to act as a part of the research and development department of the factory and detect the source of the problems then overcome it by answering twelve questions. At the end of the case, there was also information about auto-ionization of water, pH, and pOH and water hardness under the “background knowledge” part.

The first question was asking the reason of water in the factory being hard. The second question was asking the reason of water having lower pH values. The third question was asking the ways to overcome the water hardness problem whereas the fourth question was asking for the ways of overcoming the pH value problem. For answering the first four questions, the students should apply their higher order thinking skills to read the tables in the cases and decide the cause of the problems. In the fifth question, the students were asked how they think the anions and cations affect water to be acidic or basic. By the help of these questions, it was aimed to improve students’ critical thinking skills and create their own explanations accordingly (here the teacher should give tips for the students to think about

Bronsted-Lowry acids and bases for guiding to the students). The next three questions were again aimed to improve students' higher order thinking skills and their logic since they were asked to make connections between the pH and H^+, pOH and OH^-, and pH and POH then express the relation as a mathematical equation. The next three questions were about the students' misconceptions about measure of acidity/basicity (see Demircioğlu, Ayas, Demircioğlu, 2005; Garnett, 1995; Metin, 2011) or what a high number of pH or pOH means according to properties of acidity. The last question was about another important concept which was amphoteric structure of some acids and bases. The students needed to analyze the equation given in the background knowledge to answer this question. The aim of asking this question in this part was making the students get into cognitive conflict when they check the related equation so that meaningful learning will be more probable to occur.

3.8.2.5 Pınar's Table Lamp

The main of developing this case was making an interdisciplinary teaching with physics since this case included electric circuit and the electric current to pass through.

Another concept that is important and reason of students' misconception was the percent dissociation of acids and bases and the acid/base dissociation constants (Demerouti, Kousathana, and Tsaparlis, 2004; Smith and Metz, 1996). For this reason this case was designed so that each concept should be taught to students. The students also needed to learn to use these concepts in problem solving. Thus, some questions based on this case included mathematics to be used to answer the questions. In this scenario, Pınar's table lamps' wire is break down and she knew that she could light the bulb of the lamp if she could produce some electric circuit with some solutions. She tried three different solutions on the bulb and observed the change in the light degrees for these solutions. After the scenario, there was a part called "back ground knowledge" in which the students were given a brief explanation about the strong/weak acids and the dissociation constants/ percentages.

According to the scenario, there were eleven questions many of which were designed to improve students' critical thinking and problem solving skills. The first question was asking the reason of the related solution being the most glowing. The second question was asking the reason of the related weak base solution being the least glowing instead of the other weak acid solution. The third question was asking if another solution was prepared how the bulb lighting would change. These four questions needed the students to understand the logic behind the lighting degrees' cause while discussing in groups and reading the "background knowledge" part. In the next question, there was information given to the students about the dissociation constants and the dissociation ratio and it was asked if the statement was true or false. In order to answer that it was also asked the students to apply mathematics and justify their answer with it. The next question has some sub questions in it too. They were mainly asking for ordering the strength of acids according to the given table in the case. And there was another sub question that was designed to help students develop their own relation between the acid and its conjugate base or base and its conjugate acid. Then the other sub-question asks if these relations could be generalized for all acids and bases. The next designed for making the students order the acids and bases according to the given dissociation constants and justifying their answer with the chemical bonds and periodic table units of chemistry. So, one important aim of this question was helping the students remember what they learned in the previous units of chemistry and make the connections with logical explanations. The next questions asked to the students were for overcoming or protecting students to have a known misconception by always making students apply mathematics and justify their answers then make their comments, explain the possible reasons related to it and make generalizations or for practicing, reinforcing the mathematical connection related to the acid/base dissociation constants. So, the students had no blanks about the related concepts.

3.8.2.6 Stomach's Enemy: Ulcer

This case was designed for explaining the neutralization reactions and titration concepts of acids and bases. In addition to that, it was aimed to protect students from the misconceptions related to these two concepts. The case was about a girl's mother being ulcer that she checks for the reasons behind this illness. What she finds was given in the "background knowledge" part of the case. With this case, again interdisciplinary teaching was taken into account. In addition to that making students aware of this health problem was another aim of the study.

At the end of the case, there were twenty-one questions. They were trying to make the students realize the chemistry behind this illness and the cure methods of it. In addition to that, the related concepts according to neutralization reaction and titrations were tried to be internalized to the students, the students tried to be protected from having the misconceptions related to these concepts, students' higher order thinking skills were tried to be improved by asking them to draw graphs related to the given cases and mathematical skills were also tried to be developed with some questions.

3.8.2.7 Making Our Own Fuel with Biodiesel

As it could be understood from its name, in this case, the process of making fuel by using the biodiesel was planned to be studied by some students at the weekends in the laboratory of their school but they did not know what to do next. They need some help for the situation. By this case, it was aimed to make students gain information about the futures' fuel source and make them familiar with the strong acid and weak base reactions and the titrations between them. After the scenario there was another "background knowledge" part that briefly explains how to apply acid-base chemistry during this process especially for purification of residual oil.

After the case, there were six questions accordingly. The first questions was asking if the residual oil had more free fatty acids how would the base in the reaction affected from it. By this question, after the previous case, the students' were checked if they understood the logic behind the titration of acids and bases. The second and third questions were questioning why titration is a more important process when the residual oil is used instead of pure oil and why it was a three step process. This question was simply designed for making the students' see the different areas that the titration process should be used and it may be a crucial step. In addition to that, since biodiesel is the future's fuel source, this question was also designed for learning the fuel making process from biodiesel by heart. The fourth question asked the strength of acid used during the fuel making process. This question was designed for improving students' critical thinking skills and for helping them to make inferences accordingly. The fifth question was asked if the students' should differentiate the types of titrations (strong acid- strong base, strong acid-weak base, weak acid-strong base) and it was explored if after learning about strong acid-strong base and strong acid- weak base titrations the students think all titration types occur with the same logic or not. In order to answer these, students also need to make inferences from what they knew about titrations until that time. The last question was designed for the students if they could transfer their knowledge about strong acid-weak base titrations into strong base-weak acid titrations. For answering this question, students needed to apply their higher order thinking skills since they needed to draw the graph about it.

3.8.2.8 Selçuk's Water Boiler

Till this time, the students learned about the three titration types which were the strong acid- strong base, strong acid-weak base and they made generalization according to these knowledge about weak acid- strong base titrations. In this case, it was planned to include weak acid- weak base titrations into the equation and since water hardness is an important concept for students to apply in their daily life, it was also rechecked to get feedback about their learning process.

The case was about the water boiler that includes some lime at the bottom. For this reason, Selçuk tried different methods to make the lime go away which were successful up to different points but he did not control the time so that he was confused about their order of being effective. So, he needed some assistance to decide the order of the effectiveness of each method he applied. At the end of the case there was another "background knowledge" that briefly gives information about the lime, its structure, which reactions it should enter etc.

There were nine questions related to this case. The first two questions asked if the students could write the equation between vinegar and lime or lime dissolver and lime. With these two questions, the students were evaluated according to their knowledge about chemical reactions, balancing a chemical reaction and if they could realize carbon dioxide gas to be out of the reaction. Then, in the third question, the students were asked to make their explanations about the given case based upon acid-base chemistry. The next questions asked to the students next were all designed to make students remember some crucial points about acids and bases. By this way the students were also checked if they understood what had been done until that time and the feedback was used for improving the next lectures. Then in the fourth question, the students were asked to make the connection between this case and the water hardness since they were asked the reason of the formation of lime to be more in the hard waters. The fifth question was simply designed for making the students realize the strength of lime and differentiate it from the other daily life materials since it was asking for the strength of the materials Selçuk conducted the tests with. The sixth question was designed for making the students remember the relation between the equilibrium constants of strong acid and weak acid by asking to compare the equilibrium constants of the materials Selçuk conducted the tests with. Seventh question designed for making the students remember relation between the strength of acids and their ionization percentage in water in which they were asked to fill a given table according to their answers to fifth and sixth questions. The eighth question was simply asking for the most successful strategy to remove the lime from the water and the reason behind it according to the given answers to the previous questions. In the ninth question the students were asked if they could order the given acids according to their strengths since their ionization percentages were given in a table which was also a recalling question.

3.8.2.9 Acid-Base Equilibrium in Our Body

First of all this case was designed by taking the interdisciplinary teaching into equation once again with biology. The main aim of this case was teaching the students about the buffer solutions, their daily life usage areas and their importance in our body and all living organisms.

In the case, Onur had realized the doctor gave a drug to his mother that was created a health problem known as metabolic acidosis. So he searched for this illness from the internet and gets some information about it even if Onur had some more questions that needed to be answered about the illness and asked for assistance to answer them.

There were seven questions related to this question. The first three questions were designed for the students to make connections between acids and bases and the given case in terms of buffer solutions. The first question was searching for the scientific explanation for Onur's mother to use that drug in order to cure the illness. In this question, the students were expected to make the connections between acid-base concepts and this case. In the second question, it was asked why the drug could never be used if the values about the blood were basic. The third question asked what to do for being protected from the illness. Then the students were asked if there might be another illness that is opposite to acidosis. In this question students needed to use their critical thinking skills and creativity since there was no information or clue in the given case. The fifth question directly asked the reason of the buffer solutions being in our body. The students should criticize the case to correctly answer this question since it was hidden in it. For making the students link the buffer solutions and conjugate acid-base pairs; the sixth question was asked. It was simply asking the reason of buffer solutions to include conjugate acid-base pairs. For this question only thing the students need was making inferences. Then for making the students think and search, the next question was asked; where the buffer solutions should be found in our daily life.

3.8.2.10 Plants and Salts

The plants and salts case was developed since the other part the students had many misconceptions according to acid and bases was about salts and as mentioned in another case, the anion/cation acidity or basicity. Since one of the curriculum objectives was being able to give examples to the salts that include high positive charged cations and neutral anions in its structure, this question was composed of many steps to follow one by one to learn, differentiate and at the end, reach the objective.

In the case, there was a panel conducted about growing plants. Some youths joined the panel and they were examining an article about it. In the article there were different types of plants and the conditions for growing the plants. The conditions include pH of the soil, temperature, light and moist they love to have. The youths were given a list of salts and their formation reactions by the trainer in the panel and it was asked them to differentiate the salts that each plant should reach and not.

After the case, there twelve questions asked to the students. In the first question the character of the salt was asked (acidic/basic or neutral) by thinking about the strength of acid and bases the salts were composed of according to the given list in the case. In the second question, the students were asked to categorize the possible salts that could be reached and could not by the given plants. In the third question, the students were asked to write the hydrolysis reactions of the salts from the list in the case. The third question was asked to differentiate the anions and cations of each salt and find the characteristic of the salt as it was found in the first question. At this point there was a sub-question to compare these two questions' results. Since all needed to be the same. In the fifth question, it was asked about the conjugate acids and bases of the cations and anions of the salts from the list. Sixth question asked for comparing the strengths of the anions and their conjugate acids whereas in the seventh question it was asked to compare the strengths of the cation and its conjugate base. After these questions, the next questions should be easily answered according to the answers related to the previous answers. One of these questions was directly asked for the objective in the curriculum; that seek for an examples to the salts that include high positive charged cations and neutral anions in its structure.

3.8.2.11 Ayşegül's Puzzle with Onion (if time is left)

This case was developed if there would be some time left during the study. It was simply searching for the reason of cutting the onion under water. The answer to this question could be given by the help of acids and bases which was also explained in the “background knowledge” part of the case.

As a general view, the cases mainly included factual things inside especially in the “background information” parts. In addition to that, all the cases designed to motivate students to learn acid-base chemistry. These cases were applied to the students all the same way by the help of case based learning. After the treatment, both groups were administered ABT and CMQ as a post-test to determine students’ understanding of the acids and bases concepts and their motivation towards chemistry by analyzing each construct of the CMQ test. Some examples to the cases/scenarios developed for this study were also given in the Appendix G.

3.8.3 Presentation Activity

At the end of the study, in the experimental group, a presentation that was designed to cover up and summarize students’ misconceptions related to acids and bases concepts was introduced to the students.The aim of applying this activity was for making different experimental groups equal in terms of knowledge of misconceptions since in experimental classes, as the discussion environment was conducted, different misconceptions should be determined and overcomed. Thus, for making all experimental group classes equal, this presentation was formed and applied. It was prepared as a game of knowledge contest so that this presentation was an inquiry-based activity in which the student were all active and answering the questions in the presentation while the teacher managed the presentation and give chance to students explain their reasoning behind their answers for each question according to what they learned. For this reason, there was again a discussion environment in the class. This activity took two class hours to be completed. After the study, this activity was also applied in control group students. Some slides developed for the presentation were introduced in the Appendix H.

3.8.4 Misconceptions in Cases and Presentation:

As mentioned above, in many cases, during lecture hours and in the presentation prepared by the researcher, the students were introduced some misconceptions related to the acids and bases concepts from the literature since CBL instruction was found to be effective in overcoming students’ misconceptions (e.g. Çam & Geban 2013, Yalçınkaya et al., 2012). The Table 3.6 below summarizes these misconceptions and where they were found in the cases of this study:

Table 3.6 Misconceptions in cases and presentation

Misconceptions	Case Name	Question # /Option
*For acids/bases to be strong or weak affect their acidic/basic properties.	Karate Kids	4/c
*All acids and bases are organic.	Acids and Bases in Our Daily Life	4
All acids are poisonous (Demirci, Özmen, 2012)	Acids and Bases in Our Daily Life	4
All bases are poisonous (Demirci, Özmen, 2012)	Acids and Bases in Our Daily Life	4
All acids are harmless (Demirci, Özmen, 2012)	Acids and Bases in Our Daily Life	2/a,4
All bases are harmless (Demirci, Özmen, 2012)	Acids and Bases in Our Daily Life	1/a
All acids and bases could be touched (Demirci, Özmen, 2012)	Acids and Bases in Our Daily Life	4
All acids and bases could be tasted (Demirci, Özmen, 2012)	Acids and Bases in Our Daily Life	1/c,2/c
All acids are useful (Demirci, Özmen, 2012)	Acids and Bases in Our Daily Life	2/a,4
All bases are useful (Demirci, Özmen, 2012)	Acids and Bases in Our Daily Life	1/a
All acids are harmful to our health (Demirci, Özmen, 2012)	Acids and Bases in Our Daily Life	3

Table 3.6 Misconceptions in cases and presentation (continued)

Misconceptions	Case Name	Question # /Option
Bases could be in the taste of sour and bitter (Demirci, Özmen, 2012)	Acids and Bases in Our Daily Life	4
All the fruits are acidic (Demirci, Özmen, 2012)	Acids and Bases in Our Daily Life	1/b,4
Fruits are basic (Nakhleh & Krajcik, 1994; Ross & Munby, 1991)	Acids and Bases in Our Daily Life	2/b, 4
It could not be mentioned about the effect of acids or bases in the taste of fruits (Demirci, Özmen, 2012)	Acids and Bases in Our Daily Life	1/b,2/b,4
Since fruits show basic properties, they taste sour, vegetables show acidic property so that they taste bitter (Demirci, Özmen, 2012)	Acids and Bases in Our Daily Life	2/b, 4
Artificial acids give serious damage to people (Yurttagül & Ayaz, 2008)	Acids and Bases in Our Daily Life	3
The usage of acids and bases in industry could only be by artificial production of them (Yurttagül & Ayaz, 2008)	Acids and Bases in Our Daily Life	3
*When the basic foods were eaten, they always make the blood basic	Acids and Bases in Our Daily Life	5
*When the acidic foods were eaten, they always make the blood acidic	Acids and Bases in Daily Life	5
For a matter to be acidic, it has to include hydrogen (H) in its structure (Demircioğlu, Ayas, Demircioğlu, 2005)	Purification of Water	6

Table 3.6 Misconceptions in cases and presentation (continued)

Misconceptions	Case Name	Question # /Option
• In an acidic solution; $[H^+] < [OH^-]$ • In an acidic solution; $[H^+] = [OH^-]$ • In an acidic solution; $[OH^-] > 1x10^{-7}$ • In an acidic solution; $[H^+] < 1x10^{-7}$ (Morgil et al, 2002)	Purification of Water	6
• In a basic solution; $[H^+] > [OH^-]$ • In a basic solution; $[OH^-] = [H^+]$ • In a basic solution; $[OH^-] < 1x10^{-7}$ • In a basic solution; $[OH^-] < 1x10^{-7}$ (Morgil et al, 2002).	Purification of Water	7
For a matter to be basic, it has to include hydroxide (OH) in its structure (Demircioğlu, Ayas, Demircioğlu, 2005)	Purification of Water	7
pH was only the measurement of acidity (Metin, 2011).	Purification of Water	9
pOH was only the measurement of basicity (Metin, 2011).	Purification of Water	10
When the pH value increases, the acidic properties also increase (Metin, 2011).	Purification of Water	11
When the pOH value increases, the basic properties also increase (Metin, 2011).	Purification of Water	11
If the concentration of OH^- ion increases, pOH also increases (Metin, 2011).	Purification of Water	11
$H_2CO_3 + H_2O \leftrightarrow H_3O^+ + HCO_3^-$ • (Base 1 + Base 2 ↔ Acid 1 + Acid 2) • (Acid 1 + Base 1 ↔ Base 2 + Acid 2) • (Base 1 + Acid 1 ↔ Acid 2 + Base 2) • (Acid 1 + Acid 2 ↔ Base 1 + Base 2) (Morgil et al, 2002)	Purification of Water	12

Table 3.6 Misconceptions in cases and presentation (continued)

Misconceptions	Case Name	Question # /Option
$HCO_3^- + H_2O \leftrightarrow H_3O^+ + CO_3^{-2}$ • (Base 1 + Base 2 ↔Acid 1 + Acid 2) • (Acid 1 + Base 1 ↔ Base 2 + Acid 2) • (Base 1 + Acid 1 ↔ Acid 2 + Base 2) • (Acid 1 + Acid 2 ↔ Base 1 + Base 2) (Morgil et al, 2002).		
As the Ka constant increases, the strength of acid decreases (Morgil et al, 2002).	Pınar's Table Lamp	5/a
When a weak acid is diluted, ionization percentage does not change (Yalçın, 2011).	Pınar's Table Lamp	6
When a weak acid is diluted, ionization percentage decreases (Yalçın, 2011).	Pınar's Table Lamp	6
When a weak acid is diluted, the acidity constant decreases so that the ionization percentage also decreases (Yalçın, 2011).	Pınar's Table Lamp	6
When the indicators are not used, the neutralization reactions does not occur (Demircioğlu, Ayas, Demircioğlu, 2005).	Stomach Enemy: Ulcer	7
*When the indicators are not used, titrations could not be conducted.	Stomach Enemy: Ulcer	8
For acid and bases to give neutralization reactions, they have to be equal in terms of concentrations (Yalçın, 2011).	Stomach Enemy: Ulcer	10
For acid and bases to give neutralization reactions, both of them have to be strong Schmidt (1991)	Stomach Enemy: Ulcer	11
When weak acid and strong base were mixed equally in terms of volume and concentrations, the salt solution occurs as the final product becomes neutral (Yalçın, 2011).	Stomach Enemy: Ulcer	12

Table 3.6 Misconceptions in cases and presentation (continued)

Misconceptions	Case Name	Question #/Option
*When weak acid and strong base were mixed equally the pH of the surrounding never becomes 7.	Stomach's Enemy Ulcer	13
*Strong acid- strong base, strong acid - weak base, weak acid - strong base, weak acid - weak base titrations were always carried out in the same way.	Making Our Own Fuel with Biodiesel	5
Since vinegar is a stronger acid than lime, vinegar dissolves lime (Demirci & Özmen, 2012).	Selçuk and Water Boiler	3
Vinegar and lime were both acids. Since only an acid could dissolve another, lime is dissolved with vinegar (Demirci & Özmen, 2012).	Selçuk and Water Boiler	3
Lime dissolver and lime were both acids. Since only an acid could dissolve another, lime is dissolved with lime dissolver (Demirci & Özmen, 2012).	Selçuk and Water Boiler	3
*A buffer solution could be prepared by using only acid/only base.	Acid base Equilibrium in Our Body	6
For acids to be ionized, water was not needed.	Presentation Activity	-
All the matters/solutions that include hydrogen (H^+) in their structure were acids (Demircioğlu, Ayas, Demircioğlu, 2005).	Presentation Activity	-
All the matters/solutions that include hydroxide (OH^-) in their structure were bases (Demircioğlu, Ayas, Demircioğlu, 2005).	Presentation Activity	-
The strength of acids is directly proportional with the number of hydrogen atoms in their structures (Demircioğlu, Ayas, Demircioğlu, 2005).	Presentation Activity	-

Table 3.6 Misconceptions in cases and presentation (continued)

Misconceptions	Case Name	Question # / Option
A strong acid/base is always concentrated (Demircioğlu, Ayas, Demircioğlu, 2005).	Presentation Activity	-
*Weak acids/bases do not conduct electricity	Presentation Activity	-
The strength of different acids/bases is the same when they have the same concentration (Yalçın, 2011).	Presentation Activity	-
*There are no hydroxide (OH^-) ions in the aqueous solution of the weak acid.	Presentation Activity	-
For the constant temperature, the larger the acid/base constant, the smaller the percentage of the ionization of acid/base. So there is a reverse proportion between them (Yalçın, 2011).	Presentation Activity	-
The smaller the Ka or Kb values, the stronger the acids/bases (Morgil et al., 2002).	Presentation Activity	-
*When the initial concentration of a weak acid/base is increased, the dissociation ratio also increases.	Presentation Activity	-
*When the initial concentration of a weak acid/base is decreased, the dissociation ratio also decreases.	Presentation Activity	-
*The weak acids' conjugate bases are also weak and strong acids' conjugate bases are also strong.	Presentation Activity	-
*The weak bases' conjugate acids are also weak and strong bases' conjugate acids are also strong.	Presentation Activity	-
When a strong acid and strong base give neutralization reaction, the solutions formed after the reaction always has a pH of 7 (Schmidt, 1991).	Presentation Activity	-

Table 3.6 Misconceptions in cases and presentation (continued)

Misconceptions	Case Name	Question # /Option
*When a strong acid and strong base gives a neutralization reaction, the salts formed after the reaction shows acidic/basic or neutral properties according to the acids/bases' initial proportions in the reaction.	Presentation Activity	-
In a neutralization reaction, when one of the reactants (acid or base) is weak, the neutralization does not completely take place (Pınarbaşı, 2007).	Presentation Activity	-
*When the elements that were in the same period made compounds with hydrogen, the acid strength of these compounds increase from right to left.	Presentation Activity	-
*Acidic strength of the HX type of compounds that were in the same group increases from bottom to top.	Presentation Activity	-
*In the periodic table from top to bottom, the strength of the bases increases in the same group whereas it decreases from right to left in the same period.	Presentation Activity	-
*When number of oxygen atoms attached to central atom increases, the strength of acidity decreases.	Presentation Activity	-
*The acidic strength of the oxoacids that were in the same group but have different central atoms increases as the electronegativity of the central atom decreases.	Presentation Activity	-
The values of pH and pOH could not be equal or smaller than 0 (Metin, 2011).	Presentation Activity	-
The values of pH and pOH could not be equal or bigger than 14 (Metin, 2011).	Presentation Activity	-
*Indicators measure the pH interval instead of pH value.	Presentation Activity	-
*The anions of the strong acids also show acidic properties.	Presentation Activity	-

*: This misconception was formed by the researcher for the present study

3.9 Teacher Lesson Plans

The lesson plans for the experimental group teachers were prepared in terms of predetermined objectives. These lesson plans then, were reviewed by two different experts in chemistry to make corrections when necessary on the prepared lesson plans. According to the expert opinions, some misunderstood wordings and wrong spellings that the teachers might came face to face were corrected by the researcher.

Then, the final forms of the teacher lesson plans were formed and before the implementation, they were given to experimental group teachers of this study since they would get some hints when necessary about the implementation or the answers to the questions for all cases. Thus, in the lesson plans, not only the objectives but also previous knowledge needed to learn the concept of the days, the important parts about how the lectures should flow, what needed to be done by the teacher before/during /at the end and after each lecture and the related misconceptions to be mentioned in each case were given. By preparing the teacher lesson plans and wanting the teachers to follow the general structure written in these lesson plans, treatment validity was tried to be controlled.

An example of a teacher lesson plan was given in the Appendix I part of this study.

3.10 Ethical Problems

In order to overcome the ethical problems, first of all, the permissions from the relevant department of Ministry of Education of Turkey (MEB) were gathered. After the permission was given, the schools were selected randomly. Before beginning to study, both teachers and students were informed about the study so they would not be deceived. Students were also informed about the confidentiality.

Confidentiality of the research data was also ensured as not giving name of the schools, teachers and students. Students were told to have a right to withdraw from the study if they wanted and the result of the tests would not be used for evaluating them. In addition to these, a consent form from both teachers and students were collected.

3.11 Analysis of Data

Before beginning to the study, students were given pretests of ABT and CMQ. Then, in the last week of the rate and equilibrium chapter, the students were introduced the case based learning method with one application about equilibrium. Then, acid-base chapter of chemistry was studied for ten weeks. There were three hours a week for chemistry lesson. The lectures were observed as much as possible by the researcher. Then, at the end of the study, posttests of ABT and the CMQ were administered again in both the high school of Ankara and science high school of Karabük.

After the study finished, the collected data from pretests and posttest were analyzed by using a statistics package program, called SPSS. The descriptive statistics; mean, median, standard deviation, skewness and kurtosis were calculated for both treatments for summarizing, organizing and simplifying the data and for controlling the assumptions of the inferential statistics. MANCOVA was used to determine and compare the effectiveness of the two different schools, general high school and general science high school and two different treatments, CBL and traditionally designed instruction on students' understanding of acids and bases concepts and their motivation to learn chemistry.

MANCOVA becomes more important and become more useful in experimental studies in which there is manipulation over at least some of the independent variables. This method has more advantages when compared to ANCOVA. First of all by making the analysis in one step rather than much more steps with ANCOVA, the Type I errors caused by these several analysis were decreased as much as possible. Second, since more than one dependent variable in one analysis, the main factor that is affecting the study in a high degree could be found more easily. Also this method could reveal differences that couldn't be found by using several ANCOVA tests (French et al., 2002). For the related reasons, in this study the MANCOVA analysis were conducted to see the effect of different treatments and different schools on students' understanding of acids and bases concepts and their motivation to learn chemistry.

Even if the study was tried to be done in a controlled way, some extraneous variables, like the size of the classroom, time of the lessons and the day the lecture took place were difficult to be controlled. The researcher chosen the close class hours for all groups participating in this study whereas, it couldn't be done perfectly. So these variables were accepted as the confounding variables that couldn't be controlled.

Sample size was 298 since there were 4 classes in Ankara with a total of 143 students, 4 classes in Karabük with a total of 145 students and 10 students from the pilot study of the tests, eight of whom are from the same Anatolian High school in Ankara and the other two students were from the same science high school in Karabük studied during the main study. But since there were some missing data in the study, at the end the sample size was 292 students. In an experimental study, sample size of 30 is appropriate for a group (Frankel & Wallen, 2006). In this study there were 146 students in the experimental group and 146 students in the control group. It is approximately four times to five times greater from the recommended sample size.

In order to assess students' motivation scores, after the reverse coding was done for the anxiety construct of motivation (for pre-SE and post-SE), each scores were added under the related construct to form each dependent and independent variables according to motivation.

Moreover, in order to see the change in students' understanding, each question in the pre and post ABT test were analyzed by descriptive statistics so that it would be a good way to compare each questions' effect on students' understanding of acids and bases concepts.

3.12 Handling Missing Values and Data

During the study, it was expected to have some missing values and data during the testing process. For this reason, in order to overcome problems caused by the missing values or data, which were mainly found in the middle of the tests, an option with the name of "I don't know" was inserted into the ABT. So that, when a student came face to face with a question that s/he couldn't answer, the option was selected by him/her so that some missing values or data would be handled by the researcher.

There were some missing values in the pre-test and post-test even if they were tried to be handled. For this reason, the reasons of the missing data was tried to be defined. Since some missing data were found at the end of the tests, then the reasons were taught to be not finishing the test in the given time or they were bored. If the blank missing data were still in the middle or at the beginning, then the reason would be the students passed the questions accidentally. Since students' lack of knowledge was controlled by the inserted "I don't know" option.

When there were some missing data in the variable, the following procedure was followed (Cohen & Cohen, 1983):

a. The missing data was checked to be in dependent variable or in independent variable. If it was in dependent variable, then all data of the subject was erased by list wise deletion.
b. If missing data was in independent variable, then the independent variable was checked whether it was continuous or categorical. If it was categorical, then all data were erased.
c. If the missing data was in a continuous independent variable, the percentage of the missing data was determined:
    i. If the percentage was below 5%, then the missing data was replaced by mean.
    ii. If the percentage was above 20%, then missing data was deleted by column-wise deletion.
    iii. If the percentage was between 5% and 20%, the researcher used statistics. In other words, a dummy variable was created. This variable included only 1 and 0 in which, 1 corresponds to the missing data and 0 corresponds to not missing. Then the dummy variable and dependent variable of the test were analyzed by t-test to test for significance. When it was significant, then the dummy variable and independent variable were blocked. When not significant, then dummy variable was deleted, and the missing data would be replaced by mean.

At the end of these processes, in the study, there were 2 subjects lost (since they were in the categorical independent variable) and 11 subjects replaced by mean (since they were in the continuous independent variables which were then used as covariates) according to possible reasons mentioned above.

3.13 Power Analysis

There are some factors that affect the error rates. One of them is the statistical power. The power of the test has a great importance since if a study does not have adequate power, it will not have the capacity to produce the quality of evidence necessary for deciding effectiveness of a study (Spybrook, 2008). When α value, sample size and effect size are given, the power of the test may be evaluated (Cohen, 1977).

According to the literature, the effect size of the studies about case based learning is evaluates as large (Choi & Lee, 2009; Papadopoulos, Demetriadis & Stamelos, 2007;   Rybarczyk, Baines, McVey, Thompson & Wilkins, 2007). So, according to the literature, the effect size of this study was expected to be large as well. The α value that was the probability of making Type 1 error (or rejecting a true null hypothesis), was set as .05 and β value which is the probability of making Type 2 error (or failing to reject a false null hypothesis), was set as 0.2. Sample size was calculated using Cohen's power table (1977) for large effect size as 26 per group. Since there are two groups, the needed sample size was equal to 52. When the researcher used this information, power of the test was evaluated as 0.8.

In this study, the sample size included 292 subjects. So, the power was found as greater than 0.995 according to Cohen (1977) which was high.

3.14 Assumptions

For this study to work, there were some assumptions made. They were;

- Students in experimental group did not interact with students in the control group.
- The teacher who applied the treatment was not biased.
- The tests were administered under standard conditions.

- All students gave accurate and sincere responses to all items in the instruments used in the study.

3.15 Treatment Fidelity and Treatment Verification

In this study, the treatment called case based learning (CBL) was applied to the students. Case based learning is founded on the constructivism approach and it is a form of problem-based learning. So, it wouldn't be wrong to conclude that it is mainly based on a theory.

In this study, the main purpose was to compare the effectiveness of an instruction based on case based learning with the traditionally designed instruction on 11th grade high school students in terms of students' understanding of acids and bases concepts and their motivation to learn chemistry. For this reason, the study included a test to measure students' understanding and another test to measure students' motivation to learn chemistry. Since one of our main objectives in this study was to compare two treatments with each other, after pretest, the treatment was given to experimental group with appropriate case scenarios and lesson plans explained to the teachers that were also trained to administer the case based learning. After the treatment, the posttests to assess students' motivation and understanding were again administered. So that, with the collected data from pretest and posttest, it would be possible to evaluate the mean differences of the scores that would give information about the effectiveness of both treatments.

The case scenarios, Acids and Bases Test (ABT) and lesson plans were prepared by the researcher by taking the objectives from the 11th grade chemistry curriculum into account next to the literature, text books and the teachers' opinions who were taking a part in this study. After the preparation, they were given to three experts in order to check the correctness of each of the case scenarios, ABT questions and lesson plans and to check if they really were about what they supposed to be about for content validity. After the feedback taken from the experts, a pilot study was administered on twelve 12th grade students (ten students' data were used in this study because of two students not completing the implementation) of the same high schools of the study. After the data were collected, lesson plans, ABT questions and case scenarios were evaluated if they work or not. In addition to this, they were criticized according to the usage of time. The lectures were 45 minutes and the materials that were prepared by the researcher were applicable in one or two lecture hours. They shouldn't be longer or shorter. So that, at least one lecture hour from each week should be left to summarize the concept of the week, analyze misconceptions in a detailed way and solve related problems when necessary. In other words, the time was adjusted for each material by the help of the feedback taken from the pilot study when necessary. When the correction of the tests was provided, the test was assumed to be ready to be administered in the study.

By applying these steps in the study, treatment fidelity and verification were tried to be provided. But, during the study, there were some external events that were unexpected. For example, during the study in Ankara, a teacher in the school was died unexpectedly. So, the students were very upset and they did not want to be a part of the study that week. In this situation, the researcher let the week to pass empty for students to gain their motivation back and postponed the study a week later. Actually, when some unexpected events occur during the studies, the researchers should find a way to complete their administration by comforting students, finding a way to connect the unexpected event to the lecture or etc. However, in this situation nothing could be done, the lecture was postponed to the next week's lecture hour but it was not passed. However, passing one week empty brought some advantages to the study since as leaving one week empty in Anatolian high school, the researcher move to Karabük and found a chance to observe more lectures than usual. However, a disadvantage was also occurred: one case had to be cut off from the study which was not designed for teaching a new concept but to enhance the concept. Although it was an unfortunate result, there was not a big loss for the study since this case was actually designed by for sighting this kind of events to occur. So that, it could be easily cut off from the study.

3. 16 Teacher Training

Before the study, teachers were needed to be trained because even if they had a will to learn new techniques, the trainings they were given were not enough. So in order to help them to gain a deeper understanding, they were instructed about the case based learning (CB), its advantages and disadvantages, its contributions to the students etc. in their free hour times before the study begin. Then the sufficient explanation about the administration of the case scenarios and lesson plans were provided to them. A sample of an instruction based on case based learning was introduced to the teachers for better understanding. Their suggestions, advices according to the materials were taken, some decisions of the formation of the groups were discussed and some feedback about the students' characteristics was also gathered from the teachers. Then if teachers had any questions that confused their minds, they were answered. After the training, the teachers were asked to teach the case scenarios to test their understanding. While one teacher was explaining a case scenario, the researcher was mainly listening carefully and taken notes to evaluate teachers' performances. Then the researcher was able to collect evidence about teachers' being appropriate to the study.

This study was conducted for comparing the effectiveness of an instruction based on CBL with the TDIM in terms of 11^{th} grade student's understanding of acids and bases concepts and their motivation to learn chemistry. What was expected from this study was finding an instruction based on case based learning to be more effective than traditionally designed instruction in terms of students' understanding and learning that result in higher achievement in students and their motivation to learn chemistry was also expected to be more effective in the favor of CBL instruction. For this reason, the results of the above problem should show a significant mean difference favoring case based learning. If it was not found to show a significant mean difference, than it was not possible to say that an instruction based on case based learning was effective when compared to traditionally designed instruction.

3.17 Budget and Time Schedule

The budget of the study was also an important detail to be decided. The budget included printing of the tests. As there were 292 students in this study, many colorful copies of ABT test, The CMQ, Lesson plans and case scenarios were needed that would cost approximately 1500 TL. In order to conduct the study, the researcher needed to travel to Karabük from Ankara some times. So, it was another part of the budget. There were so many lessons to be observed that the researcher needed to be transported from Ankara to Karabük for two days in a week. So it cost approximately 500 TL.

The study began in the 2013-2014 spring semester. For that reason, the case scenarios, lesson plans, ABT and The CMQ copies in excess amount, permission from the related department were collected till that time. The time schedule was given in Table 3.7.

Table 3.7 Time schedule of the study

Preparation of the lesson plans and case scenarios	October 2014
Revision of the lesson plans, ABT test questions and case scenarios	December 2014
Design of the instruction based on case based learning	January 2014
Teacher training	February 2014
Collection of the consent forms	March 2014
Application of the instructions and data collection	April 2014
Data Analysis	July 2014

CHAPTER 4

RESULTS AND CONCLUSIONS

In this chapter, the results of the data analysis were given including the following three sections: missing data analysis, descriptive statistics and inferential statistics.

4.1 Missing Data Analysis

Before beginning to descriptive and inferential statistics analysis, it was crucial to control the missing values in the collected data that showed up during the study. For this reason, the missing analysis was conducted on a total of 298 students.

Before beginning to missing value & data analysis, first of all, there were four students that were excluded from the study since one of them from the science high school were preparing for the competition so that they couldn't enter the first three weeks of the study and the pre-tests. The other three students were from the Anatolian high school and two of them did not want to be a part of the study by their will and the other one had some health problems so that she missed the last four weeks of the study. For this reason, the missing data analyses were done on 294 students. In addition to this, before beginning to the missing data analysis, the researcher had the students' list for each classroom so that if a student did not write his/her name or school to the tests, the researcher found their schools easily. Table 4.1 shows the frequency statistics before beginning to the deep analysis:

Table 4.1 Frequency statistics of the data before missing data analysis

		Pre-ABT	Pre-SE	Pre-ANX	Pre-GO	Pre-IM	Pre-SD
N	Valid	290	291	292	294	291	293
	Missing	4	3	2	0	3	1
Mean		65,46	30,71	14,35	24,72	18,89	20,12
SD		7,58	4,14	4,052	4,67	2,85	2,16
Variance		57,52	17,11	16,42	21,81	8,13	4,67
Skewness		,21	-,03	,18	-,06	,09	,02
Kurtosis		-,58	-,44	-,60	-,32	-,69	-,57
Minimum		49	20	5	13	11	16
Maximum		82	40	24	35	25	25

Table 4.1 Frequency statistics of the data before missing data analysis (continued)

Post-ABT	Post-SE	Post-ANX	Post-GO	Post-IM	Post-SD	GRP	SCH
294	294	294	294	294	294	292	294
0	0	0	0	0	0	2	0
81,87	32,07	19,41	26,44	19,74	20,41	1,5	1,5
10,82	4,31	2,76	5,056	2,88	2,60	0,50	0,50
117,10	18,62	7,61	25,57	8,28	6,74	0,25	0,25
-,17	-,32	-,34	-,42	-,22	-,16	-,01	,00
-,10	-,75	-,35	-,42	-,52	-,81	-2,01	-2,01
58	20	12	12	12	15	1	1
100	39	25	35	25	25	2	2

In addition to this, missing data analysis was conducted. Table 4.2 shows the univariate statistics at the beginning of the operations and the Figure 4.1 below shows the missing values & data percentages in terms of variables, cases and values before beginning to the analysis:

Table 4.2 Univariate statistics by missing value analysis before handling missing data

Variables	N	Mean	S.D.	Missing	
				Count	Percent
Pre-ABT	290	65,4552	7,58388	4	1,4
Pre-SE	291	30,7148	4,13618	3	1,0
Pre-ANX	292	14,3527	4,05235	2	,7
Pre-GO	294	24,7211	4,66968	0	,0
Pre-IM	291	18,8900	2,85058	3	1,0
Pre-SD	293	20,1229	2,16097	1	,3
Post-ABT	294	81,8707	10,82108	0	,0
Post-SE	294	32,0748	4,31457	0	,0
Post-ANX	294	19,4082	2,75818	0	,0
Post-GO	294	26,4422	5,05617	0	,0
Post-IM	294	19,7449	2,87740	0	,0
Post-SD	294	20,4184	2,59662	0	,0
Group	292			2	,7
School	294			0	,0

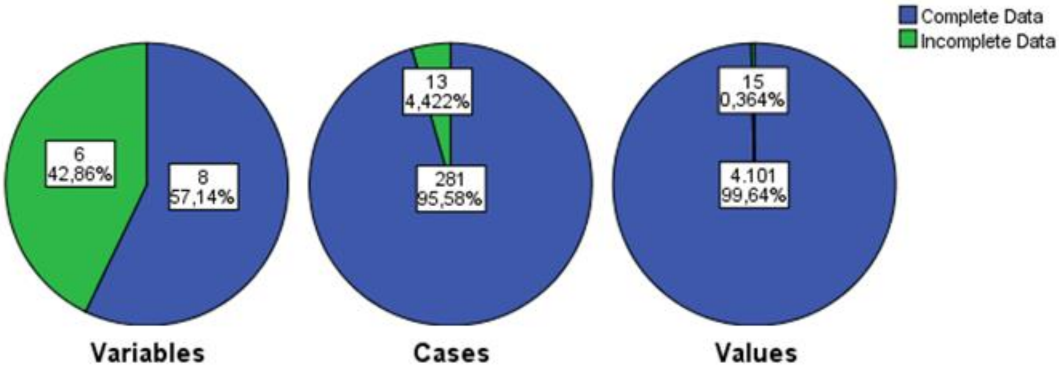

Figure 4.1 Overall summary of missing values before handling missing data

After these decisions were done, the missing data were begun to be analyzed. As mentioned before when there were some missing data in the variable, first it was checked if the missing data was in the dependent variable which were the post-ABT and post-CMQ constructs (post-SE, post-ANX, post-GO, post-IM and post-SD). There were not any subjects that have missing data in the post-CMQ or post-ABT tests since the problematic data were already excluded at the beginning of the analysis. So, there was no need to conduct a list wise deletion action.

Then the missing data was checked in the independent variables. One of the independent variable was school which was categorical. Since the researcher collected the students list from each class of each school, the students were aimed to be identified to prevent having missing data in the study. For this reason, after the controls, there were four students detected to forget to write their schools and they were written on their papers accordingly in order to overcome missing data problem. The other independent variable was group which was also categorical and there were two subjects from the Anatolian high school that forgot to write their names on their tests. However, these students could not be identified since they were from the same school but from different groups. In other words, it was not possible to decide the groups of these students since there were two of them. As it was mentioned before, for the categorical independent variables, if there were missing subject then they were excluded from the study. Thus, these two subjects were excluded from the study and there were 292 students in the study.

Lastly, for the continuous independent variables which are the pre-ABT and pre-CMQ constructs (pre-SE, pre-ANX, pre-GO, pre-IM and pre-SD), the percentage of the missing data was determined as less than 5%. For this reason, the missing data was replaced by mean to overcome the problems that may be caused by the missing data. The Table 4.3 shows the means of pre-ABT and pre-CMQ constructs' scores:

Table 4.3 Means for pre-ABT and constructs of pre-CMQ tests

		Pre-ABT	Pre-SE	Pre-ANX	Pre-GO	Pre-IM	Pre-SD
N	Valid	290	291	292	294	291	293
	Missing	4	3	2	0	3	1
Mean		65,4552	30,7148	14,3527	24,7211	18,8900	20,1229

As it could be seen from the table, four subjects were replaced by the mean of 65.46 for pre-ABT scores, three subjects were replaced by the mean of 30.71 for pre-SE scores, two subjects were replaced by the mean of 14.35 for the pre-ANX scores, three subjects were replaced by 18.89 for pre-IM scores and one subject is replaced by 20.12 for pre-SD scores. Since there were no missing data in pre-GO construct of CMQ, its mean was not used. The Table 4.4 below and the Figure 4.2 show the statistics after the missing data was handled during the study:

Table 4.4 Univariate statistics for the variables after handling missing data

Variables	N	Mean	S.D.	Missing	
				Count	Percent
Pre-ABT	292	65,47	7,56	0	,0
Pre-SE	292	30,69	4,12	0	,0
Pre-ANX	292	14,40	4,02	0	,0
Pre-GO	292	24,66	4,63	0	,0
Pre-IM	292	18,88	2,84	0	,0
Pre-SD	292	20,13	2,16	0	,0
Post-ABT	292	81,89	10,86	0	,0
Post-SE	292	32,03	4,30	0	,0
Post-ANX	292	19,39	2,76	0	,0
Post-GO	292	26,41	5,06	0	,0
Post-IM	292	19,72	2,87	0	,0
Post-SD	292	20,40	2,60	0	,0
Group	292			0	,0
School	292			0	,0

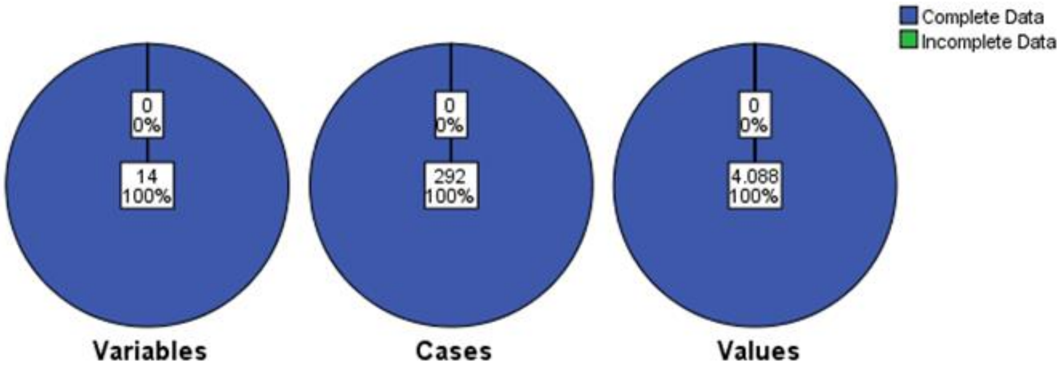

Figure 4.2 Overall summary of missing values after handling missing data

4.2 Descriptive Statistics

In this part, the descriptive analysis results of the study were given. Firstly, the descriptive statistics given in the Table 4.5 shows the excluded scores after missing data analysis which was the descriptive statistics about pre-ABT, pre-CMQ constructs, post- ABT, post- CMQ constructs in terms of group independent variable:

Table 4.5 Descriptive statistics in terms of group independent variable

		N	Mean	Difference (cont.-exp.)	S.D.	Min.	Max.
Pre-ABT	Control	145	65,47		7,06	52,00	82,00
	Experimental	147	65,46	-0,01	8,04	49,00	82,00
Pre-SE	Control	145	30,64		3,97	23,00	40,00
	Experimental	147	30,75	0,11	4,28	20,00	40,00
Pre-ANX	Control	145	14,72		3,93	7,00	24,00
	Experimental	147	14,08	-0,64	4,09	5,00	24,00
Pre-GO	Control	145	24,60		4,70	13,00	35,00
	Experimental	147	24,73	0,13	4,58	14,00	34,00
Pre-IM	Control	145	18,86		2,69	14,00	25,00
	Experimental	147	18,90	0,04	2,99	11,00	25,00
Pre-SD	Control	145	19,95		2,26	16,00	24,00
	Experimental	147	20,30	0,35	2,06	16,00	25,00
Post-ABT	Control	145	74,23		7,80	58,00	100,00
	Experimental	147	89,44	15,21	7,69	61,00	100,00
Post-SE	Control	145	31,07		4,25	21,00	39,00
	Experimental	147	32,99	1,92	4,15	20,00	39,00
Post-ANX	Control	145	19,17		2,64	12,00	24,00
	Experimental	147	19,61	0,45	2,87	12,00	25,00
Post-GO	Control	145	25,00		4,76	12,00	35,00
	Experimental	147	27,80	2,80	4,98	13,00	35,00
Post-IM	Control	145	19,04		2,62	13,00	25,00
	Experimental	147	20,38	1,34	2,95	12,00	25,00
Post-SD	Control	145	19,88		2,29	15,00	25,00
	Experimental	147	20,92	1,04	2,78	15,00	25,00

According to the results of Table 4.5, it could be accepted as the pre-ABT, pre-SE, pre-ANX, pre-GO, pre-IM and pre-SD mean scores before the implementation were almost the same for the both groups and the correct answer rate for these tests were low since most students were not sure for their responses even if many of them had already studied this unit in special courses out of school. The small differences were in the favor of control group for the pre-ABT and pre- ANX mean scores whereas they were in the favor of experimental group for pre-SE, pre-GO pre-IM and pre-SD mean scores. For the post test, all mean scores become higher in the favor of experimental group including the highest increase in the ABT mean scores. Thus, it could be concluded that, the mean scores of pre-ABT (students' understanding) and pre-ANX (anxiety) constructs' scores for the control group was a bit higher when compared to the experimental group before the implementation whereas; at the end of the study this result changed in the favor of experimental group.

The possible maximum score for the pre-ABT test was 100 and the highest score in terms of group was 82 for both experimental and control group. The possible highest scores for the pre-SE, pre-ANX, pre-GO, pre-IM and pre-SD are 40, 25,35,25,25 respectively. And for the control group the highest scores were 40, 24, 35, 25, and 24 respectively where as they are 40, 24, 34, 25 and 25 respectively for the experimental group. The possible highest scores for the post-SE, post-ANX, post-GO, post-IM and post-SD are 40,25,35,25 and 25 respectively as mentioned above. The students mean scores for control group were found as 39, 24, 35, 25 and 25 respectively and it is 39, 25, 35, 25 and 25 for the experimental group.

As a result, it could be concluded that students differ in their pre-test results a bit at the beginning of the study when the mean scores of the variables were grouped in terms of treatment, CBL for the experimental group and TDIM for the control group. But since it was a small difference, they could be accepted as not different from each other at all. The gain scores and their percentages on the ABT and CMQ constructs were given in the Table 4.6 for both experimental and control group.

Table 4.6 Gained scores for control and experimental group after the implementation

Name of the Test	Group	Gained Score (Posttest-Pretest)	Gained Percentages ((Posttest-Pretest) / Posttest) x 100
ABT	Control	8,76	11,80 %
	Experimental	23,98	26,81 %
SE	Control	2,35	7,56 %
	Experimental	2,24	6,79 %
ANX	Control	4,45	23,20 %
	Experimental	5,54	28,22 %
GO	Control	0,40	1,60 %
	Experimental	3,07	11,06 %
IM	Control	0,18	0,94 %
	Experimental	1,48	7,25 %
SD	Control	-0,08	-0,38 %
	Experimental	0,62	2, 96 %

According to Table 4.6, when the students understanding of acids and bases concepts were analyzed, both groups' scores were found to be increased whereas, the mean of the post-ABT scores for the experimental group was higher than the one in the control group while there was found a big difference between their pre-ABT scores. It was an 11.8 % increase in the ABT scores for control group whereas it was a 26.81 % increase for the experimental group which could be accepted as twice higher from the control group's success.

In terms of post-CMQ constructs' scores, there were also a difference between the total pre-motivation and total post-motivation scores for both groups (see Table 4.5). For the control group, the change in the motivation constructs and their percentages were lower than the experimental group except the self-efficacy construct even if the difference is very low and according to Table 4.5, the experimental group students scored higher than the control group students. The increase of the motivation scores in the control group was found as 7.56%, 23.20%, 1.60%, 0.94%, -0.38% for self-efficacy, anxiety, goal-orientation, intrinsic motivation and self-determination constructs respectively and it was found as 6.79%, 28.22, 11.06%, 7.25% and 2.96% for the same constructs respectively in the experimental group. A very important point in this result was that, there was a negative score change in the self-determination construct of motivation for the control group. This means students' self-determination scores were lowered after the implementation. In addition to that, there was a great difference in terms of gained scores percentages in the goal-orientation (nearly seven times higher) and intrinsic motivation (nearly eight times higher) constructs in the favor of experimental group.

Secondly, the descriptive statistics given in the Table 4.7 which shows the excluded scores after missing data analysis which were the descriptive statistics about pre-ABT test, pre-CMQ constructs, post- ABT test, post- CMQ constructs were given in terms of school independent variable:

Table 4.7 Descriptive Statistics in terms of school independent variable

		N	Mean	Difference (cont.-exp.)	S.D.	Min.	Max.
Pre-ABT	Anatolian	146	62,11		5,66	49,00	76,00
	Science	146	68,82	6,71	7,74	49,00	82,00
Pre-SE	Anatolian	146	30,35		4,21	20,00	40,00
	Science	146	31,03	0,68	4,01	20,00	40,00
Pre-ANX	Anatolian	146	14,37		4,18	7,00	24,00
	Science	146	14,42	0,05	3,86	5,00	24,00
Pre-GO	Anatolian	146	24,21		4,66	13,00	35,00
	Science	146	25,12	0,92	4,58	14,00	34,00
Pre-IM	Anatolian	146	18,42		2,87	11,00	25,00
	Science	146	19,34	0,92	2,75	14,00	25,00
Pre-SD	Anatolian	146	20,19		2,25	16,00	24,00
	Science	146	20,06	-0,13	2,08	16,00	25,00
Post-ABT	Anatolian	146	80,03		10,76	58,00	100,00
	Science	146	83,75	3,71	10,67	61,00	100,00
Post-SE	Anatolian	146	31,79		4,28	20,00	39,00
	Science	146	32,27	0,48	4,33	21,00	39,00
Post-ANX	Anatolian	146	19,46		2,70	12,00	25,00
	Science	146	19,32	-0,14	2,83	12,00	25,00
Post-GO	Anatolian	146	26,03		5,17	12,00	35,00
	Science	146	26,79	0,77	4,93	15,00	35,00
Post-IM	Anatolian	146	19,40		2,91	12,00	25,00
	Science	146	20,03	0,64	2,80	13,00	25,00
Post-SD	Anatolian	146	20,36		2,54	15,00	25,00
	Science	146	20,44	0,08	2,66	15,00	25,00

According to the Table 4.7, for the pre-ABT scores, since one of the schools in the study was science high school in which the students have more chemistry lessons, the mean scores of the students who attend the science high school are higher than the Anatolian high school students' mean scores. For the pre- motivation constructs (pre-CMQ constructs), when the mean scores of students' pre-SE, pre-ANX, pre-GO and pre-IM were analyzed, it was found that they were a bit higher in the favor of science high school except pre-SD which was in the favor of Anatolian high school. In terms of post-ABT scores, even if the mean scores are higher in the favor of science high school, the difference between Anatolian high school and science high school mean scores was lowered (6,705 before the implementation and 3.7142 after the implementation). For the post-CMQ constructs, post-SE, post-GO, post-IM and post-SD scores are higher for the science high school whereas, for post-ANX, Anatolian high school students' scores were higher than the science high school students. It was remarkable to observe a shift to the opposite school in terms of the mean scores of post-ANX in the favor of Anatolian high school and another shift to the opposite school in terms of the mean scores of post-SD in the favor of science high school.

The possible maximum value of pre-test scores for science high school was higher when compared to the Anatolian high school students which were also expected. The possible maximum score for the pre-ABT test was 100 and it was 82 for science high school and 76 for Anatolian high school. The possible highest scores for the pre-SE, pre-ANX, pre-GO, pre-IM and pre-SD are 40, 25,35,25,25 respectively. And for the science high school the highest scores were 40, 24, 34, 25, and 25 respectively. The possible maximum score for the post-ABT test was again 100 and the highest score for science high school was 100 for both schools. The same highest scores are valid for all the post-SE, post-ANX, post-GO, post-IM and post-SD. And the students mean scores for both school types 39, 25, 35, 25 and 25 respectively.

As a result, it could be said that students differ in their pre-test results a bit at the beginning when the mean scores of the variables were grouped in terms of schools, science and Anatolian high school. However, these differences were very small for the motivational constructs that, the schools could be accepted as not different from each other in terms of the variables at all and there was a bit higher difference between the ABT scores for both schools which was ignored up to now since a deeper analysis will be conducted to overcome this error next. The gain scores and their percentages on the Acid Base Test (ABT) and motivation constructs (CMQ) were given in the Table 4.8 for both Anatolian and science high schools:

Table 4.8 Gained scores for Anatolian and science high schools after the implementation

Name of the Test	Group	Gained Score (Posttest-Pretest)	Gained Percentages ((Posttest-Pretest) / Posttest) x 100
ABT	Anatolian	17,92	22,4 %
	Science	14,93	17,8 %
SE	Anatolian	1,44	4,54 %
	Science	1,24	3,85 %
ANX	Anatolian	5,09	26,14 %
	Science	4,90	25,37 %
GO	Anatolian	1,82	7,00 %
	Science	1,67	6,24 %
IM	Anatolian	0,97	5,02 %
	Science	0,69	3,45 %
SD	Anatolian	0,17	0,84 %
	Science	0,38	1,84 %

As it could be seen from the table 4.8, an important result to be reported was that, the difference was higher in the favor of Anatolian high school students' scores for students' understanding of acids and bases concepts (from ABT), self-efficacy, anxiety, goal-orientation and intrinsic motivation constructs whereas, the difference was higher in the favor of science high school students scores for self-determination construct of motivation (from CMQ). In other words, Anatolian high school students improved their understanding, self-efficacy, anxiety, goal-orientation and intrinsic motivation constructs more than the science high school students whereas science high school students improved their self-determination construct of motivation more than Anatolian high school students.

Even if the descriptive statistics were given in terms of school independent variable, it was not clear which group of students (experimental or control group) in these schools caused these differences and as mentioned above, there was a bit higher difference between each school students' understanding (ABT) scores when compared to motivation (CMQ) constructs that was not wanted before the study that needed to be analyzed deeper. Thus, the related analysis was done accordingly: the data was split in terms of schools and descriptive statistical analysis was conducted to check the means of both group scores. By conducting this analysis, it was checked if the control group scores were lower for each dependent variable for each school. For this reason, the Table 4.9 and 4.10 shows the mean differences of each group when both schools were analyzed separately in terms of the groups, experimental and control. Table 4.9 shows the descriptive statistics according to Anatolian high school students' scores:

Table 4.9 Descriptive statistics for each group scores for Anatolian high school

		N	Mean	Difference (cont.-exp.)	S.D.	Min.	Max.
Pre-ABT	Control	71	62,00		5,04	52,00	76,00
	Experimental	75	62,22	0,22	6,23	49,00	76,00
Pre-SE	Control	71	30,77		3,98	24,00	40,00
	Experimental	75	29,96	-0,81	4,42	20,00	39,00
Pre-ANX	Control	71	15,24		3,99	7,00	24,00
	Experimental	75	13,55	-1,69	4,21	7,00	24,00
Pre-GO	Control	71	24,54		4,78	13,00	35,00
	Experimental	75	23,89	-0,64	4,55	14,00	34,00
Pre-IM	Control	71	18,62		2,69	14,00	25,00
	Experimental	75	18,24	-0,38	3,04	11,00	23,00
Pre-SD	Control	71	20,04		2,38	16,00	24,00
	Experimental	75	20,33	0,29	2,13	16,00	24,00
Post-ABT	Control	71	71,93		7,21	58,00	88,00
	Experimental	75	87,71	15,78	7,41	67,00	100,00
Post-SE	Control	71	30,72		4,11	22,00	38,00
	Experimental	75	32,81	2,10	4,21	20,00	39,00
Post-ANX	Control	71	19,18		2,36	14,00	24,00
	Experimental	75	19,72	0,54	2,98	12,00	25,00
Post-GO	Control	71	24,45		4,53	12,00	33,00
	Experimental	75	27,52	3,07	5,32	13,00	35,00
Post-IM	Control	71	18,73		2,51	13,00	25,00
	Experimental	75	20,03	1,29	3,13	12,00	25,00
Post-SD	Control	71	19,72		2,14	15,00	24,00
	Experimental	75	20,97	1,26	2,75	15,00	25,00

According to the results of the table, even if the differences were very low, pre-ABT scores in the Anatolian high school were in the favor of experimental group before the implementation whereas for the pre-CMQ constructs, they were in the favor of control group for self-efficacy, anxiety, goal-orientation and intrinsic motivation. For self-determination constructs' scores before the implementation, they were in the favor of experimental group. After the implementation, for the students' understanding of acids and bases concepts and their motivational constructs, the results were found to be in the favor of experimental group. However, since the difference was very low, both groups were accepted as equal for Anatolian high school students before the implementation.

To conclude, as it was seen from the Table 4.9, even if the difference was very low between both groups, the scores were still increased in terms of experimental group for each dependent variable after the implementation. In addition to that, the ABT scores increased more when compared to the CMQ construct scores for Anatolian high school. Table 4.10 shows the descriptive statistics according to science high school students' scores:

Table 4.10 Descriptive statistics for each group scores for science high school

		N	Mean	Difference (cont.-exp.)	S.D.	Min.	Max.
Pre-ABT	Control	74	68,80		7,15	55,00	82,00
	Experimental	72	68,83	0,03	8,35	49,00	82,00
Pre-SE	Control	74	30,51		3,98	23,00	39,00
	Experimental	72	31,57	1,05	4,00	20,00	40,00
Pre-ANX	Control	74	14,22		3,83	8,00	24,00
	Experimental	72	14,63	0,40	3,91	5,00	23,00
Pre-GO	Control	74	24,66		4,65	14,00	34,00
	Experimental	72	25,60	0,94	4,49	14,00	34,00
Pre-IM	Control	74	19,09		2,69	14,00	25,00
	Experimental	72	19,60	0,50	2,81	14,00	25,00
Pre-SD	Control	74	19,86		2,15	16,00	24,00
	Experimental	72	20,26	0,40	2,01	16,00	25,00
Post-ABT	Control	74	76,45		7,75	61,00	100,00
	Experimental	72	91,25	14,80	7,62	61,00	100,00
Post-SE	Control	74	31,41		4,38	21,00	39,00
	Experimental	72	33,17	1,76	4,11	25,00	39,00
Post-ANX	Control	74	19,15		2,90	12,00	24,00
	Experimental	72	19,50	0,35	2,76	12,00	25,00
Post-GO	Control	74	25,53		4,93	15,00	35,00
	Experimental	72	28,10	2,57	4,62	15,00	35,00
Post-IM	Control	74	19,34		2,71	13,00	25,00
	Experimental	72	20,75	1,41	2,72	15,00	25,00
Post-SD	Control	74	20,03		2,43	15,00	25,00
	Experimental	72	20,86	0,83	2,82	15,00	25,00

When the descriptive statistics of the science high school were analyzed, even if again there was a very small difference between both groups; for the ABT, before and after the implementation; the students in the experimental group scored higher than the control group students whereas the difference between both groups was higher in the post-ABT test. For the motivation constructs (CMQ), students in the experimental group scored higher than the control group students both before and after the implementation. In addition to these, it could be concluded that before the implementation the groups in the science high school could be accepted as equal since the differences were very small between both groups and there is an increase in terms of experimental group for each dependent variable after the implementation for students' understanding and motivation to learn chemistry.

When both schools' descriptive statistics (see Table 4.9 and Table 4.10) were compared in terms of pre-ABT scores of both control and experimental groups; science high school students in control and experimental groups were seemed to score higher than the Anatolian High school's control and experimental groups' students. When the pre-CMQ constructs were analyzed, again science high school control groups' students seemed to score higher than the Anatolian high school control groups' students in terms of pre-GO and pre-IM. However, Anatolian high school control group students scored higher than the science high school control group students in terms of pre-SE, pre-ANX and pre-SD. When the pre-CMQ constructs were analyzed for experimental groups, again science high school experimental groups' students seemed to score higher than the Anatolian high school experimental groups' students in terms of pre-SE, pre-ANX, pre-GO and pre-IM. However, Anatolian high school experimental group students scored higher than the science high school experimental group students in terms of pre-SD. Although there seemed to be a difference between both schools before the implementation, these differences were not very large. So, the groups in both schools were accepted as equal to each other before the implementation.

Moreover, when both schools' descriptive statistics (see Table 4.9 and Table 4.10) were compared in terms of post-ABT scores of both control and experimental groups; science high school students in control and experimental groups were seemed to score higher than the Anatolian High school's control and experimental groups' students. When the post-CMQ constructs were analyzed, again science high school control groups' students seemed to score higher than the Anatolian high school control groups' students in terms of post-SE, post-GO, post-IM and post-SD. However, Anatolian high school control group students scored higher than the science high school control group students in terms of post-ANX. When the post-CMQ constructs were analyzed for experimental groups, again science high school experimental groups' students seemed to score higher than the Anatolian high school experimental groups' students in terms of post-SE, post-GO and post-IM. However, Anatolian high school experimental group students scored higher than the science high school experimental group students in terms of post-ANX and post-SD.

Thus it can be concluded that, even if there were some differences between both schools' experimental groups' scores, both schools' experimental group students seemed to improved their understanding of acids and bases concepts and their motivation to learn chemistry very close to each other which was an evidence for CBL instruction be effective on improving students' understanding and their motivation regardless of the school types.

Table 4.11 summarizes both schools' comparisons between the control and experimental groups in terms of gain scores:

Table 4.11 Summary of the comparison of both schools' gain scores in terms of groups

	Gain Scores of Anatolian H. S.				Gain Scores of Science H.S.			
	CG	%	EG	%	CG	%	EG	%
ABT	9,93	13,5	25,49	29,1	7,64	10	22,42	24,57
SE	-0,05	-0,16	2,85	8,7	0,89	2,84	1,60	4,83
ANX	3,94	20,56	6,17	31,28	4,93	25,73	4,88	25
GO	-0,08	-0,35	0,56	13,18	0,86	3,39	2,50	8,9
IM	0,11	0,60	1,79	8,94	0,24	1,26	1,15	5,56
SD	-0,32	-1,64	0,64	3,05	0,16	0,81	0,60	2,86

According to the Table 4.11, in terms of students' understanding, the experimental groups for both schools were more successful. When motivation constructs were analyzed, again experimental group was more successful when compared to control group for Anatolian high school. However, for the science high school, all constructs of motivation (CMQ constructs) were higher in the favor of experimental group except the anxiety constructs because, control group students gained more mean scores for anxiety (ANX) construct of motivation when compared to experimental group.

When the schools' control group scores were compared, for students' understanding (ABT scores), Anatolian high school students gained more scores than the science high school students. Moreover, science high school control group students gained higher scores than the Anatolian high school control group students in terms of motivational constructs. When the schools' experimental groups were compared, it was found that in terms of ABT scores and the CMQ constructs, the Anatolian high school experimental group students gained higher scores than the science high school experimental group students except for the goal-orientation (GO) construct. In other words, for the goal-orientation constructs, the science high school experimental group students gained higher scores than the Anatolian high school experimental group students.

A remarkable result was that, students' self-efficacy (SE), goal-orientation (GO) and self-determination (SD) scores were lowered after the implementation for the control group of the Anatolian high school. In other words, students did not gain any scores; instead they lost some even if it was not a high loss. However, for science high school, there was no recession as in Anatolian high school. Another remarkable point was, for the goal-orientation construct, even if the Anatolian high school experimental group gained lower scores than the science high school experimental group students, the percentage for the gain scores of Anatolian high school experimental group students were higher than the science high school experimental group students.

The statistical analysis results will be studied in the inferential statistics part of this study for further comments and explanations. However, before that; for being sure about the score distribution to be normal, skewness and kurtosis values should be tested. The values of skewness and kurtosis in range between -2 and +2 reveal a normal distribution of scores (Field, 2009). The Table 4.12 shows the skewness and kurtosis values for all pre and posttests in terms of control group and Table 4.13 shows the skewness and kurtosis values for all pre and posttests in terms of experimental group:

Table 4.12 Skewness and kurtosis values for the control group on pre & post tests

	N	Range	Mean	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	S.E.	Statistic	S.E.
Pre-ABT	145	30,00	65,47	,343	,201	-,493	,400
Pre-SE	145	17,00	30,64	,316	,201	-,714	,400
Pre-ANX	145	17,00	14,72	,226	,201	-,570	,400
Pre-GO	145	22,00	24,60	,055	,201	-,258	,400
Pre-IM	145	11,00	18,86	,371	,201	-,818	,400
Pre-SD	145	8,00	19,95	-,035	,201	-,663	,400
Post-ABT	145	42,00	74,23	,257	,201	-,033	,400
Post-SE	145	18,00	31,07	-,059	,201	-,730	,400
Post-ANX	145	12,00	19,17	-,226	,201	-,441	,400
Post-GO	145	23,00	25,00	-,002	,201	-,338	,400
Post-IM	145	12,00	19,04	,083	,201	-,309	,400
Post-SD	145	10,00	19,88	,077	,201	-,563	,400
Valid N (list wise)	145						

a. Group = Control

Table 4.13 Skewness and kurtosis values for the experimental group on pre & post tests

	N	Range	Mean	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	S.E.	Statistic	S.E.
Pre-ABT	292	33,00	65,47	,21	,143	-,56	,284
Pre-SE	292	20,00	30,69	-,02	,143	-,41	,284
Pre-ANX	292	19,00	14,40	,18	,143	-,57	,284
Pre-GO	292	22,00	24,66	-,07	,143	-,30	,284
Pre-IM	292	14,00	18,88	,10	,143	-,67	,284
Pre-SD	292	9,00	20,13	,01	,143	-,57	,284
Post-ABT	292	42,00	81,89	-,17	,143	-1,01	,284
Post-SE	292	19,00	32,03	-,31	,143	-,74	,284
Post-ANX	292	13,00	19,39	-,32	,143	-,35	,284
Post-GO	292	23,00	26,41	-,40	,143	-,42	,284
Post-IM	292	13,00	19,72	-,22	,143	-,50	,284
Post-SD	292	10,00	20,40	-,14	,143	-,80	,284
Valid N (listwise)	292						

a. Group = Experimental

According to the table 4.12 and 4.13, it could be said that the all the continuous variables in the study were normally distributed for the both groups since the values were between -2 and +2. Figure 4.3 also shows the histograms with normal curves for the pre and posttests of the control group, and Figure 4.4 shows the histograms with normal curves for the pre and posttest of the experimental groups as an additional proof to normal distribution:

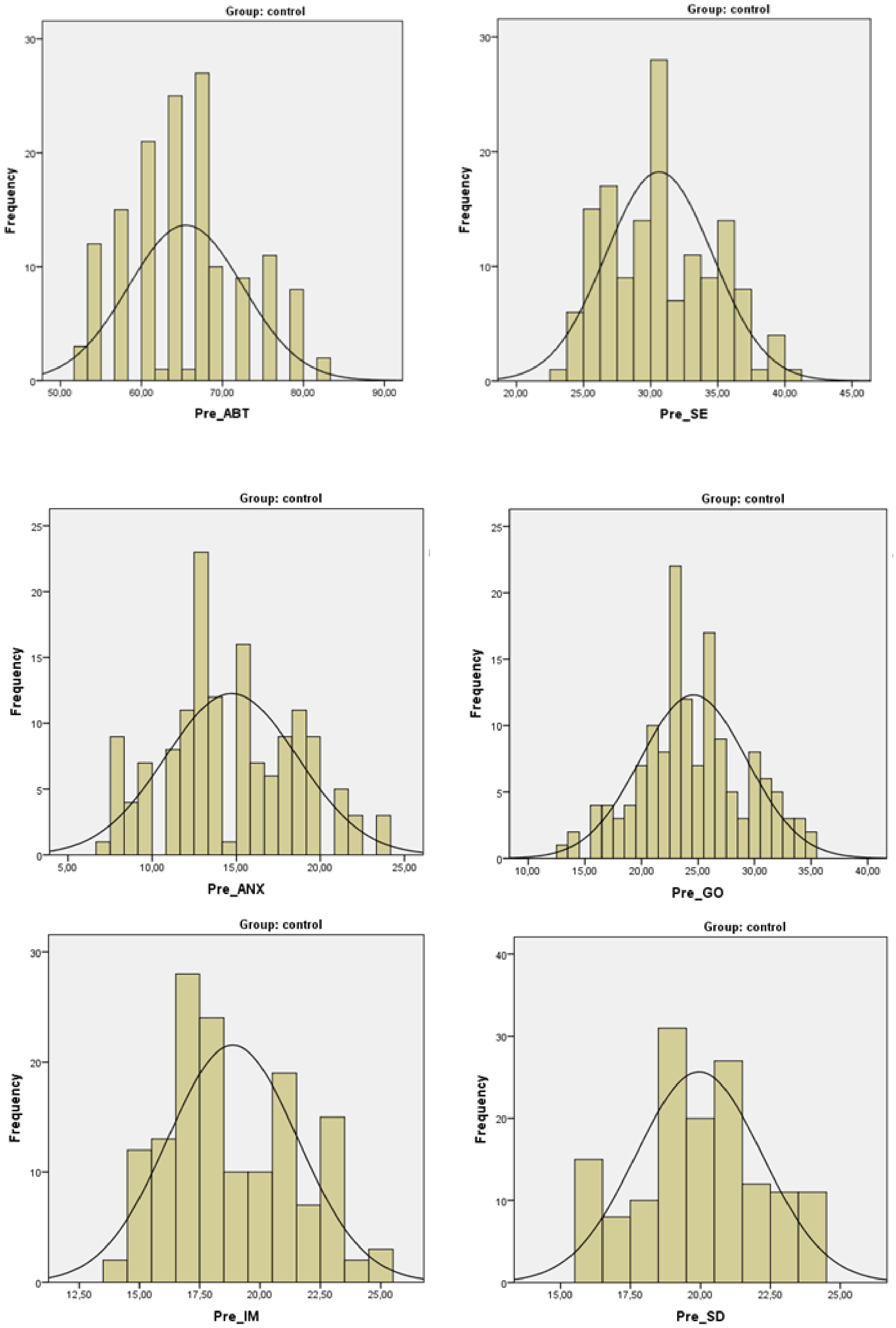

Figure 4.3 Histograms for the control group pretests and posttests

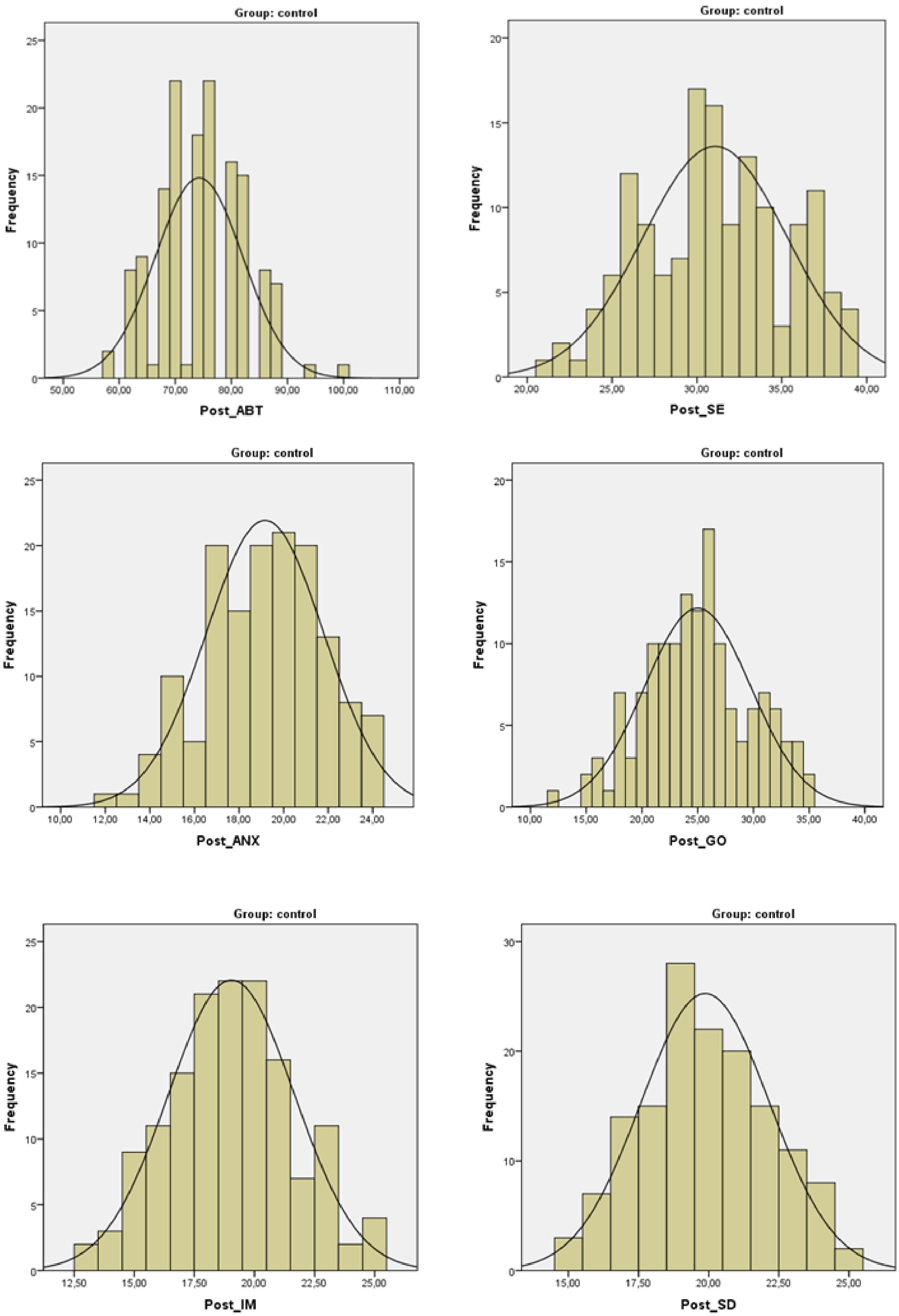

Figure 4.3 Histograms for the control group pretests and posttests (continued)

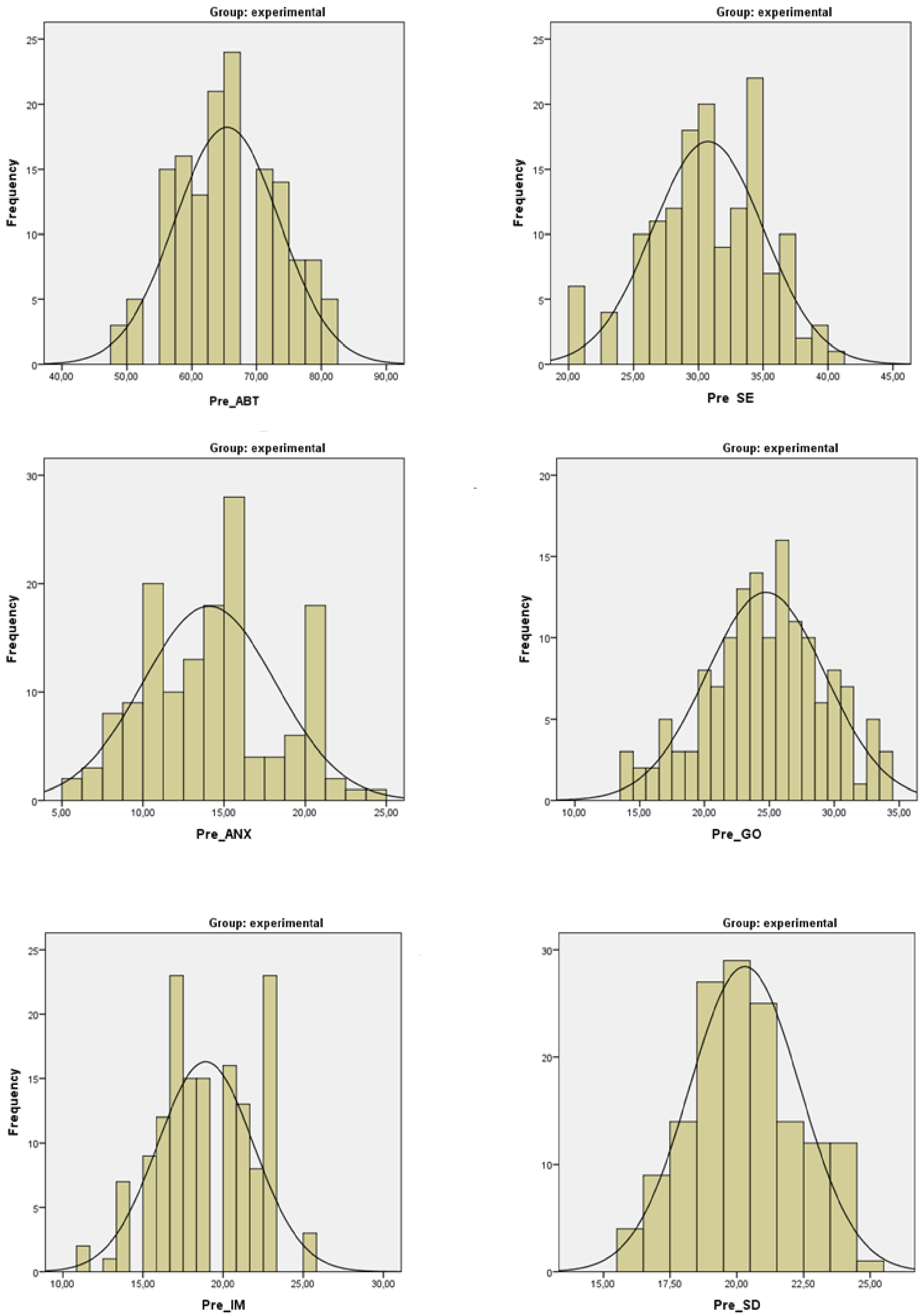

Figure 4.4 Histograms for the experimental group pretests and posttests

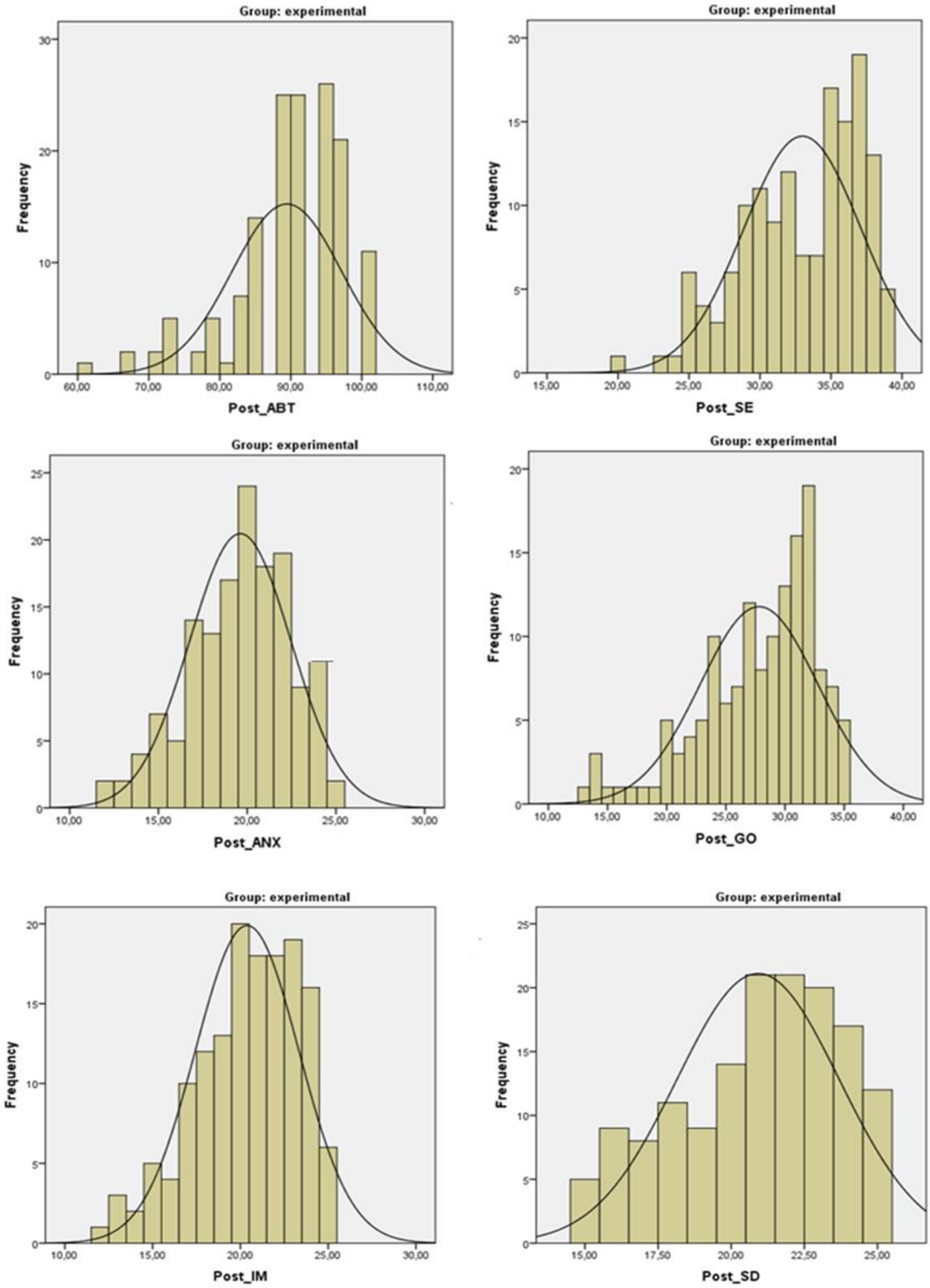

Figure 4.4 Histograms for the experimental group pretests and posttests (continued)

From the histograms, the most obvious thing to talk about was that the pre-ABT, pre-SE, pre-ANX, pre-IM and pre-SD and post-SE, post-ANX and post-IM test scores of the experimental group were wider when compared to the control group, which stated that there was more variability in the experimental group. This result could also be compared from the Tables 4.12 and 4.13 range values.

In order to check the normal distribution in terms of school types, Table 4.14 shows the skewness and kurtosis values for all pre and posttest in terms of Anatolian high school and Table 4.15 shows the skewness and kurtosis values for all pre and posttest in terms of science high school:

Table 4.14 Skewness and kurtosis values for pre & post-tests of Anatolian high school

	N	Range	Mean	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	S.E.	Statistic	S.E.
Pre-ABT	146	27,00	62,1127	,001	,201	-,365	,399
Pre-SE	146	20,00	30,3522	-,067	,201	-,536	,399
Pre-ANX	146	17,00	14,3723	,172	,201	-,835	,399
Pre-GO	146	22,00	24,2055	-,106	,201	-,246	,399
Pre-IM	146	14,00	18,4232	,103	,201	-,507	,399
Pre-SD	146	8,00	20,1918	-,055	,201	-,628	,399
Post-ABT	146	42,00	80,0342	-,120	,201	-1,039	,399
Post-SE	146	19,00	31,7945	-,416	,201	-,550	,399
Post-ANX	146	13,00	19,4589	-,263	,201	-,446	,399
Post-GO	146	23,00	26,0274	-,495	,201	-,277	,399
Post-IM	146	13,00	19,3973	-,299	,201	-,334	,399
Post-SD	146	10,00	20,3630	-,177	,201	-,718	,399
Valid N (listwise)	146						

a. School = Anatolian High School

Table 4.15 Skewness and kurtosis values for pre & post-tests of science high school

	N	Range	Mean	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	S.E.	Statistic	S.E.
Pre-ABT	146	33,00	68,8177	-,222	,201	-,715	,399
Pre-SE	146	20,00	31,0323	,070	,201	-,305	,399
Pre-ANX	146	19,00	14,4202	,184	,201	-,216	,399
Pre-GO	146	20,00	25,1233	-,015	,201	-,368	,399
Pre-IM	146	11,00	19,3425	,150	,201	-,952	,399
Pre-SD	146	9,00	20,0616	,080	,201	-,482	,399
Post-ABT	146	39,00	83,7466	-,232	,201	-1,019	,399
Post-SE	146	18,00	32,2740	-,226	,201	-,954	,399
Post-ANX	146	13,00	19,3219	-,372	,201	-,270	,399
Post-GO	146	20,00	26,7945	-,288	,201	-,677	,399
Post-IM	146	12,00	20,0342	-,116	,201	-,810	,399
Post-SD	146	10,00	20,4384	-,118	,201	-,873	,399
Valid N (listwise)	146						

a. School = Science High School

According to the Tables 4.14 and 4.15, it could be said that all pre and posttests' scores were normally distributed for both schools since all values of skewness and kurtosis were between -2 and +2. Figure 4.5 also shows the histograms with normal curves for the pre-and posttests for Anatolian high school, and Figure 4.6 shows the histograms with normal curves for the pre and posttest for the science high school.

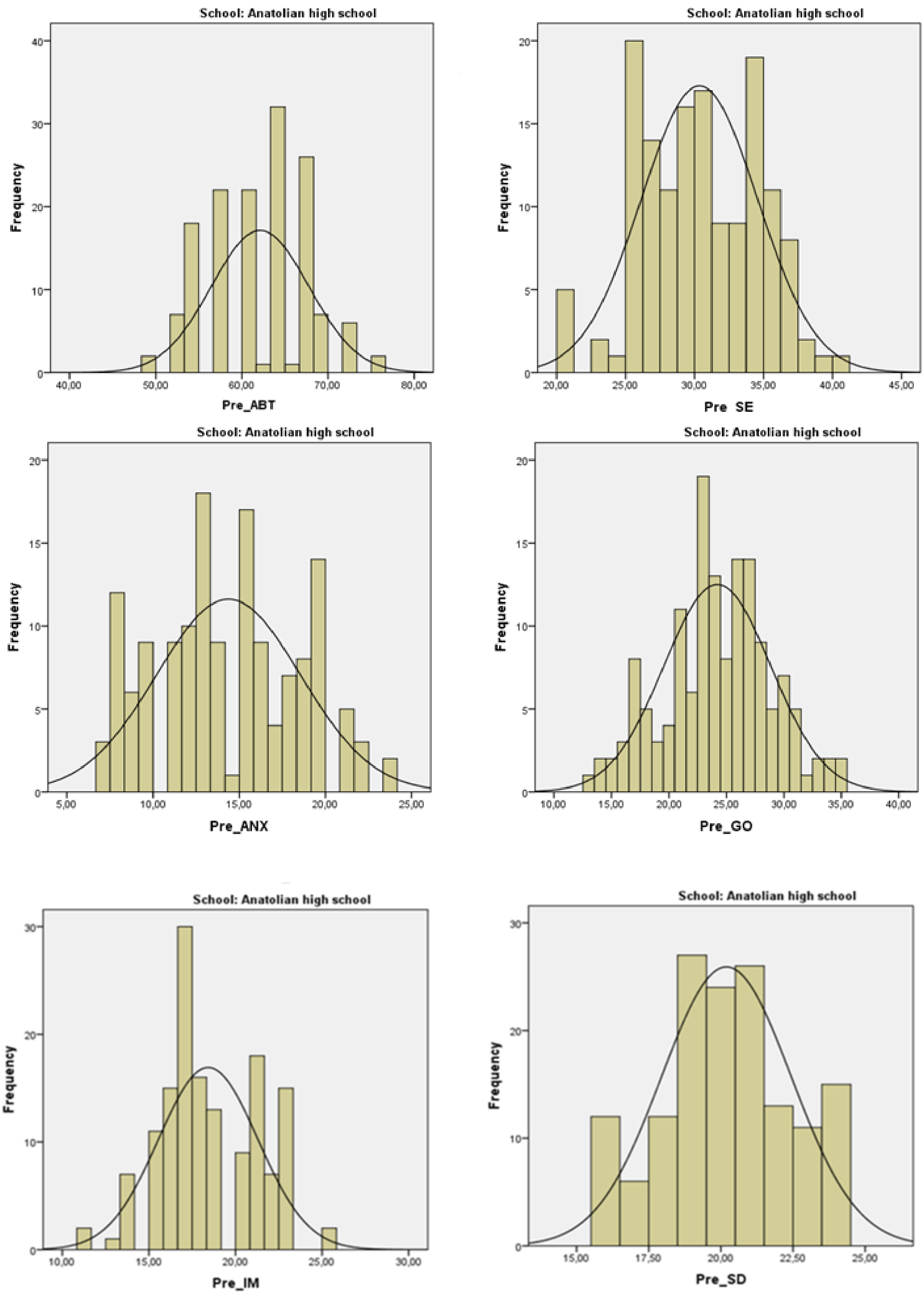

Figure 4.5 Histograms for the Anatolian high school pretests and posttests

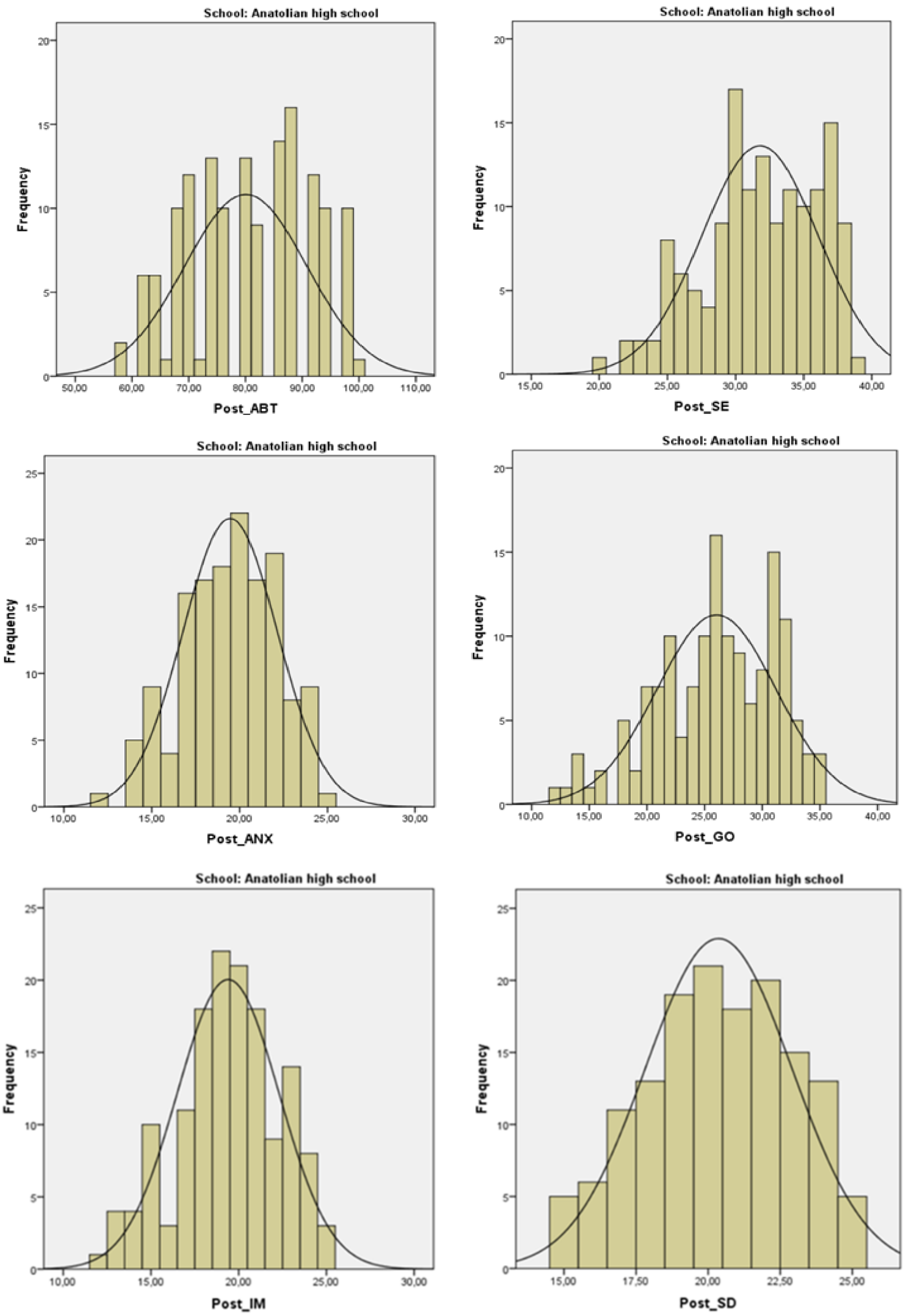

Figure 4.5 Histograms for the Anatolian high school pretests and posttests (continued)

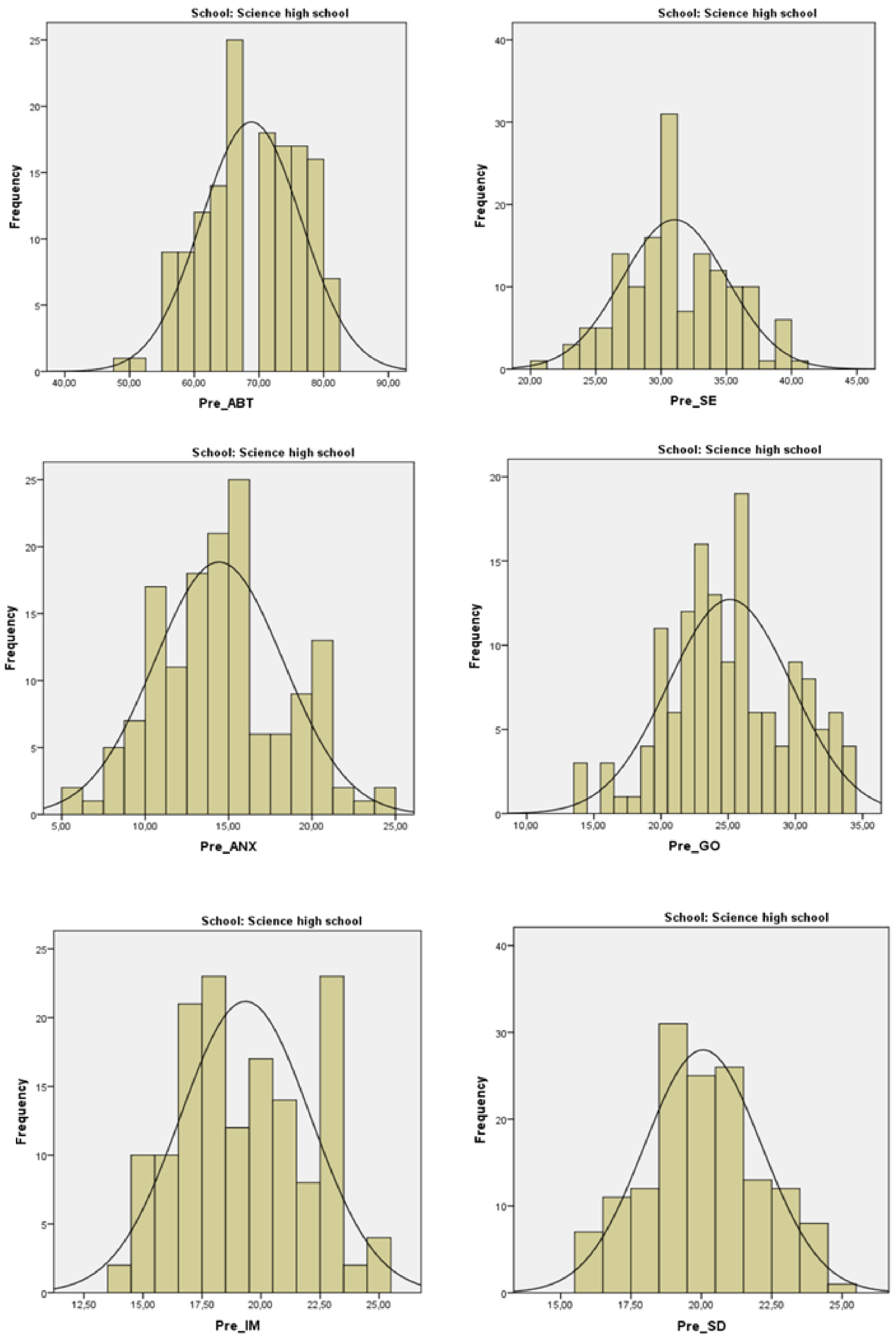

Figure 4.6 Histograms for the science high school pretests and posttests

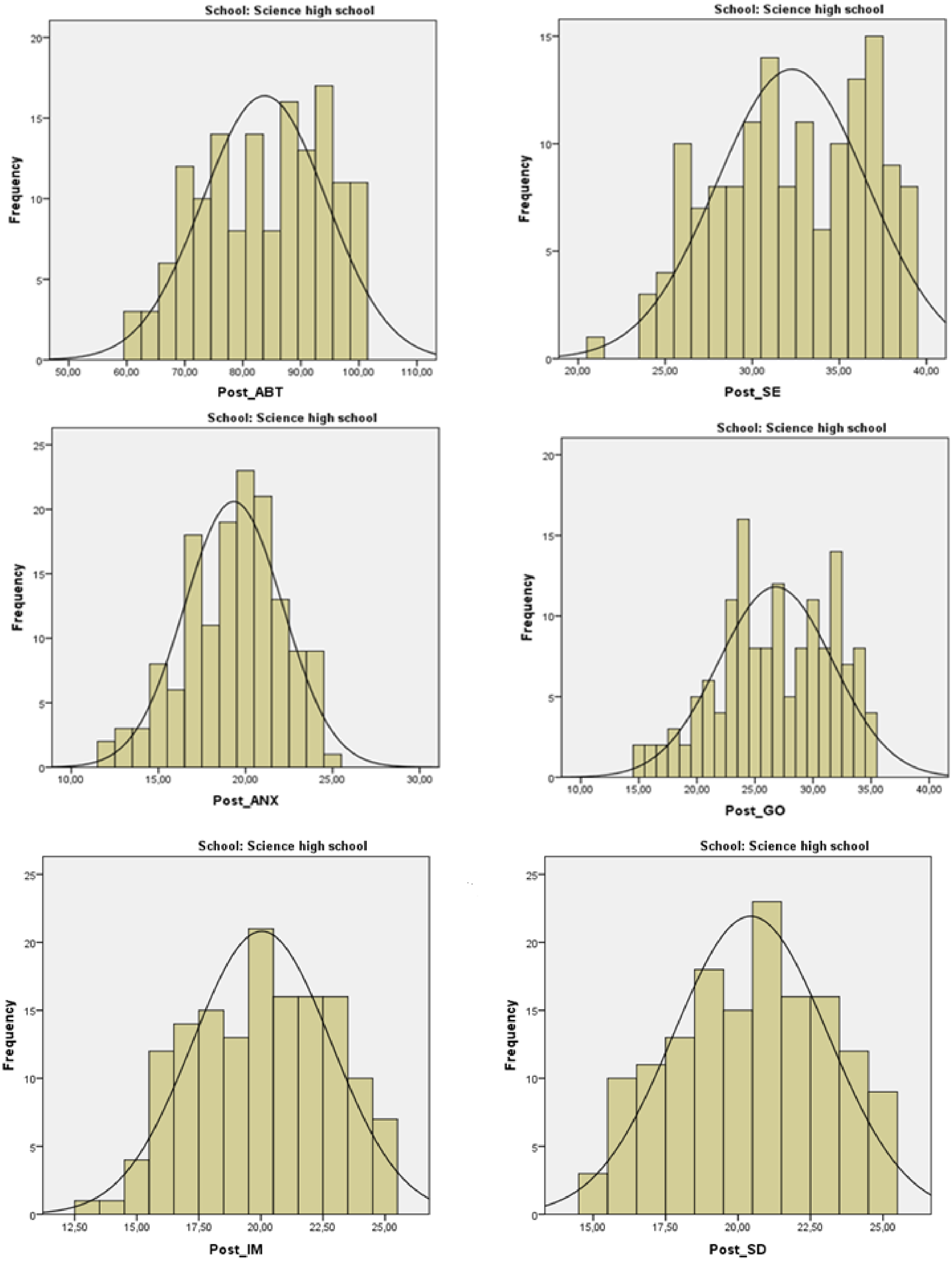

Figure 4.6 Histograms for the science high school pretests and posttests (continued)

According to these histograms and the range values from Table 4.14 and 4.15, Anatolian high school students could be accepted to have more variability in terms of pre-GO, pre-IM, post-ABT, post-SE, post-GO and post-IM whereas there was more variability in terms of pre-ABT, pre-ANX and pre-SD.

A wider view of the descriptive statistics in terms of schools and methods before running the inferential statistics was beneficial since these descriptive would provide many information and evidence for this study. In the next part, the inferential statistics were analyzed.

4.3 Inferential Statistics

4.3.1 Statistical Analysis of the Scores

After the data were collected, the first step to follow was deciding on the inferential statistics analysis to be conducted. As mentioned earlier, there were eight independent variables in the study, three of which were categorical (school and group) and six of which were continuous (pre-ABT, pre-SE, pre-ANX, pre-GO, pre-IM and pre-SD). In addition to these, there were six continuous dependent variables in the study which were post-ABT, post-SE, post-ANX, post-GO, post-IM and post-SD scores of the students. According to Graveter & Wallnau (2000), the appropriate inferential statistics test is Multivariate Analysis of Covariance (MANCOVA) that studies on two or more dependent outcomes while controlling one or more covariates across one or more independent variables (Mayers, 2013). Thus, in this study MANCOVA analysis was decided to be used. In order to conduct this analysis, first of all the possible covariates needed to be decided to go on the assumptions part to conduct MANCOVA analysis. In the next part, the decision process of covariates was explained.

4.3.1.1 Determination of Covariates

In order to conduct MANCOVA, possible covariates should be detected so that they may be decided whether used as a covariate or not. According to Tabachnick and Fidell (2007), there may be more than one covariate at the same time during the analysis if they were continuous variables, uncorrelated with each other and significantly correlated with dependent variables of the study. Pallant (2001) also mentioned about the properties about the covariates, as covariates needed to be independent from the implementation so that they shouldn't be affected from the study and if there was a correlation between covariates, it should be moderate correlation at most.

Under the light of these explanations, the possible covariates of this study were the pre-ABT, pre-SE, pre-ANX, pre-GO, pre-IM and pre-SD test scores. In order to check whether they were appropriate for this study to be used as covariates, their correlation with each other and with dependent variables (post-ABT, post-SE, post-ANX, post-GO, post-IM and post-SD) were analyzed. Table 4.16 shows the results of this correlation analyses:

Table 4.16 Correlation among all variables

	Pre-ABT Pearson Correlation	Pre-SE Pearson Correlation	Pre-ANX Pearson Correlation	Pre-GO Pearson Correlation	Pre-IM Pearson Correlation	Pre-SD Pearson Correlation
Pre-ABT	1	,031	,029	,001	,050	,008
Pre-SE	,031	1	,217**	,430**	,557**	,452**
Pre-ANX	,029	,217**	1	,029	,242**	-,123*
Pre-GO	,001	,430**	,029	1	,547**	,257**
Pre-IM	,050	,557**	,242**	,547**	1	,207**
Pre-SD	,008	,452**	-,123*	,257**	,207**	1
Post-ABT	,466**	,071	-,104	,050	,004	,040
Post-SE	,033	,514**	,245**	,452**	,541**	,266**
Post-ANX	,051	,373**	,137*	,249**	,366**	,294**
Post-GO	,069	,476**	,207**	,485**	,409**	,200**
Post-IM	,098	,431**	,195**	,420**	,459**	,286**
Post-SD	,052	,359**	,171**	,299**	,387**	,253**

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

Table 4.16 Correlation among all variables (continued)

	Post-ABT Pearson Correlation	Post-SE Pearson Correlation	Post-ANX Pearson Correlation	Post-GO Pearson Correlation	Post-IM Pearson Correlation	Post-SD Pearson Correlation
	,466**	,033	,051	,069	,098	,052
Pre-SE	,071	,514**	,373**	,476**	,431**	,359**
Pre-ANX	-,104	,245**	,137*	,207**	,195**	,171**
Pre-GO	,050	,452**	,249**	,485**	,420**	,299**
Pre-IM	,004	,541**	,366**	,409**	,459**	,387**
Pre-SD	,040	,266**	,294**	,200**	,286**	,253**
Post-ABT	1	,214**	,080	,273**	,232**	,172**
Post-SE	,214**	1	,398**	,520**	,606**	,439**
Post-ANX	,080	,398**	1	,349**	,315**	,266**
Post-GO	,273**	,520**	,349**	1	,609**	,442**
Post-IM	,232**	,606**	,315**	,609**	1	,405**
Post-SD	,172**	,439**	,266**	,442**	,405**	1

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

As it is seen from the Table 4.16, the correlation between pre-ABT and pre-SE, pre-ANX, pre-GO, pre-IM and pre-SD test scores were not significant for being covariates. However, the correlation between pre-ABT and post-ABT is significant which makes the pre-ABT applicable to be used as a covariate. For pre-SE; the correlation between pre-ANX, pre-GO, pre-IM and pre-SD were significant. For pre-ANX; pre-SE, pre-IM and pre-SD were significant. For pre-GO; pre-SE, pre-IM and pre-SD were significant. For pre-IM; pre-SE, pre-ANX, pre-GO and pre-SD were significant. For pre-SD; pre-SE, pre-ANX, pre-Go and pre-IM are significant. Thus, the CMQ constructs were all accepted as applicable to be used as covariates. Even if there need to be no correlations between independent variables; according to Pallant (2001, p. 236), there should be up to moderate correlation between these variables. As it is seen from the table, the correlations between these variables are up to moderate correlations that were acceptable. Also, the correlation between pre-SE, pre-ANX, pre-GO, pre-IM and pre-SD with the post-SE, post-ANX, post-GO, post-IM and post-SD were all significant as expected and they were up to moderate correlations.

In addition to these results, the correlation between post-ABT and post-SE, post-ANX, post-GO, post-IM and post-SD were significant. For post-SE, post-ANX, post-GO, post-IM and post-SD, all correlations between each other were also significant. According to Cohen (1988), the correlations between them were also up to moderate correlations which were true for these covariate candidates of this study.

From the results, even if the correlation between pre-ABT, post-SE, post-ANX, post-GO, post-IM and post-SD were not significant, pre-ABT needed to be assigned as covariate because of its moderate correlation with the post-ABT dependent variable. Consequently, these results revealed that pre-ABT, pre-SE, pre-ANX, pre-GO, pre-IM and pre-SD could be used as covariates for MANCOVA analysis.

After the decision about covariates was done, the numbers of students in each dependent variable were analyzed in Table 4.17 for checking their equality and they all could be accepted as equal for each independent variable.

Table 4.17 Between-Subjects Factors

		Value Label	N
Group	1,00	Control	145
	2,00	Experimental	147
School	1,00	Anatolian high school	146
	2,00	Science high school	146

In the next part, the assumptions of MANCOVA analysis will be given.

4.3.1.2 Assumptions of MANCOVA

Since it was planned to apply MANCOVA, ten assumptions needed to be met before continuing to do this analysis:

4.3.1.2.1 Level of Dependent Variables

The two or more dependent variables should be measured at the interval or ratio level (i.e., they are continuous). Since our dependent variables were post-ABT, post-SE, post-ANX, post-GO, post-IM and post-SD which were continuous, this assumption was met.

4.3.1.2.2 Level of Independent Variables

The independent variables should consist of two or more categorical, independent groups. In this study, there are two categorical independent groups which are school (Anatolian high school and science high school) and group (experimental and control). So this assumption was met.

4.3.1.2.3 Cell Size

It was important to have more subjects in each cell than the number of dependent variables of the study so that the assumptions of normality and equal variances are of less concern. In this study, each cell had at least 35 students and generally each cell had nearly equal number of students in them so that this assumption was validated.

4.3.1.2.4 Dependence

Independence of observations and tests was needed for MANCOVA to be conducted. The independence of the observations assumption was met by several ways. First of all, the researcher observed all measurement sessions for controlling whether students answered the instruments alone or together. It was ensured that each student completed the tests or questionnaires individually. In addition to that, this assumption was verified by not letting any students be in more than one group.

The assumption of independence of the test was met by letting appropriate time pass between the pretest-posttest applications (more than two months). Otherwise, the scores obtained could be somewhat similar and the dependence assumption could not be met. So, this assumption was also said to be met.

4.3.1.2.5 Outliers

Outliers are risky for MANCOVA because this analysis is very sensitive to outliers. Thus, there could be no univariate or multivariate outliers in each group of the independent variable for any of the dependent variables in this study. The univariate outliers assumption could be checked by examining histograms on Figure 4.3, 4.4, 4.5 and 4.6 since there were not any extreme scores detected and it could be said that there was no univariate outliers in the data. The outliers could also be checked by the boxplot in Figure 4.7:

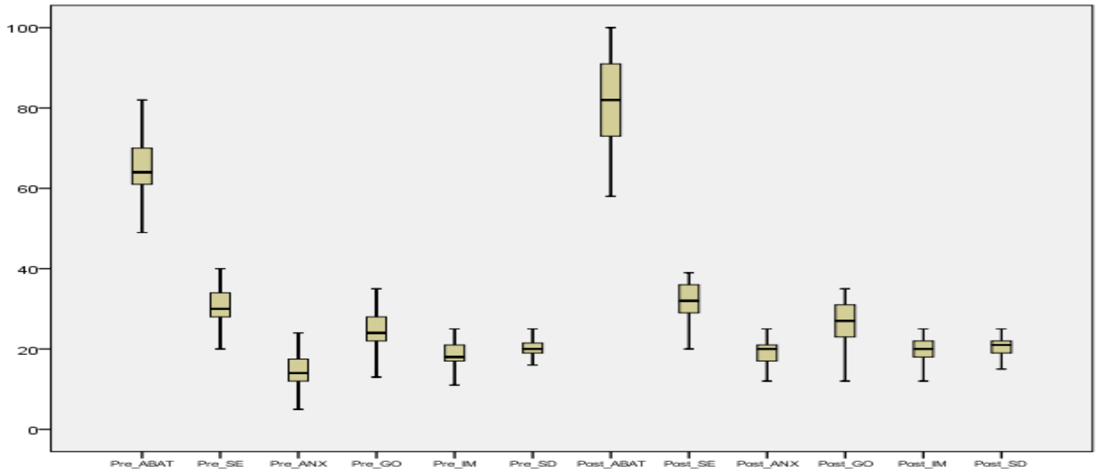

Figure 4.7 Boxplots for determining outliers

As it was also seen from the box plot, there were no outliers in this data. So, there were not any univariate outliers which mean the assumption to be met.

Multivariate outliers are the cases which have an unusual combination of scores on the dependent variables and for this assumption to be met, the measure called as the Mahalanobis distances were checked by the conducting a linear regression analysis and applying the residual statistics table (see Table 4.18):

Table 4.18 Residuals statistics for multivariate normality

	Min.	Max.	Mean	S.D.	N
Predicted Value	55,995	236,731	146,500	72,913	292
Std. Predicted Value	-1,241	1,238	,000	1,000	292
S.E. of Predicted Value	4,292	4,371	4,331	,031	292
Adjusted Predicted Value	55,837	237,703	146,503	72,914	292
Residual	-92,731	196,089	,000	42,583	292
Std. Residual	-2,170	4,589	,000	,997	292
Stud. Residual	-2,181	4,612	,000	1,002	292
Deleted Residual	-93,703	198,088	-,003	43,0250	292
Stud. Deleted Residual	-2,196	4,784	,001	1,012	292
Mahal. Distance	1,940	2,049	1,993	,043	292
Cook's Distance	,000	,072	,003	,008	292
Centered Leverage Value	,007	,007	,007	,000	292

According to the data, there were not any multivariate outliers in the data since the maximum value of the Mahalanobis distance is 2,049 which is lower than the accepted maximum since the critical value for evaluating Mahalanobis distance for two dependent variables (df = 2) is maximum 5.99 for a p value of 0.05 (Tabachnick & Fidell, 2001; Pallant, 2001). As a result, the assumption of univariate and multivariate outliers was also met.

4.3.1.2.6 Normality

For this assumption to be met, both univariate and multivariate normality needed to be checked separately. The univariate normality is accepted as the score distribution on dependent variables is normal, having a symmetrical, bell-shaped curve (Pallant, 2001). So, for the univariate normality, skewness and kurtosis values could be controlled since skewness value present information on symmetry of the distribution whereas kurtosis value present some information about the peakedness of the distribution. Tables 4.12, 4.13, 4.14 and 4.15 provide related information for this study and the values were found in the acceptable range. As a result, univariate normality assumption was met.

For checking the multivariate normality, Box’s test of equality of covariance matrices, that checks whether the hypothesis of the variance-covariance matrices is the same in groups or not could be applied (See Table 4.19). For this assumption to be met, it was expected for this test to be not significant so that, it could be concluded for the covariance matrices to be roughly equal.

Table 4.19 Box’s test of the assumption of equality of covariance matrices

Box's M	75,269
F	1,150
df1	63
df2	193715,585
Sig.	,194

As it could be seen from the Table 4.19, for an alpha level of 0.05, the Box test was not found to be significant which means the covariance matrices to be roughly equal to each other for this study. Thus, multivariate normality assumption was also met. Another way to test normality assumption, the histograms of the residuals for each variable was plotted and a symmetric distribution was checked. Figure 4.8 shows the plots in terms of groups and Figure 4.9 shows the plot in terms of schools:

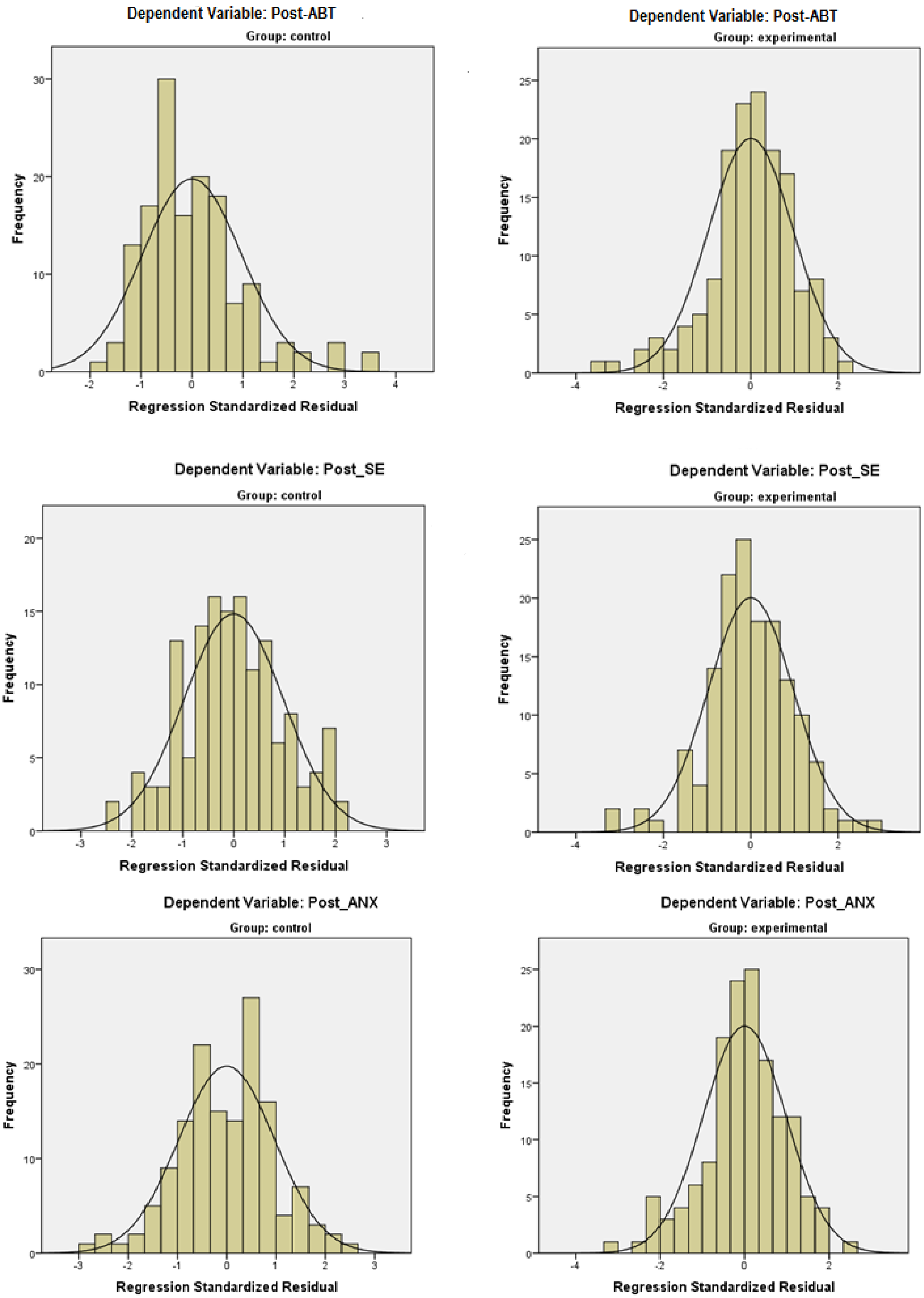

Figure 4.8 Histograms of the residuals in terms of groups

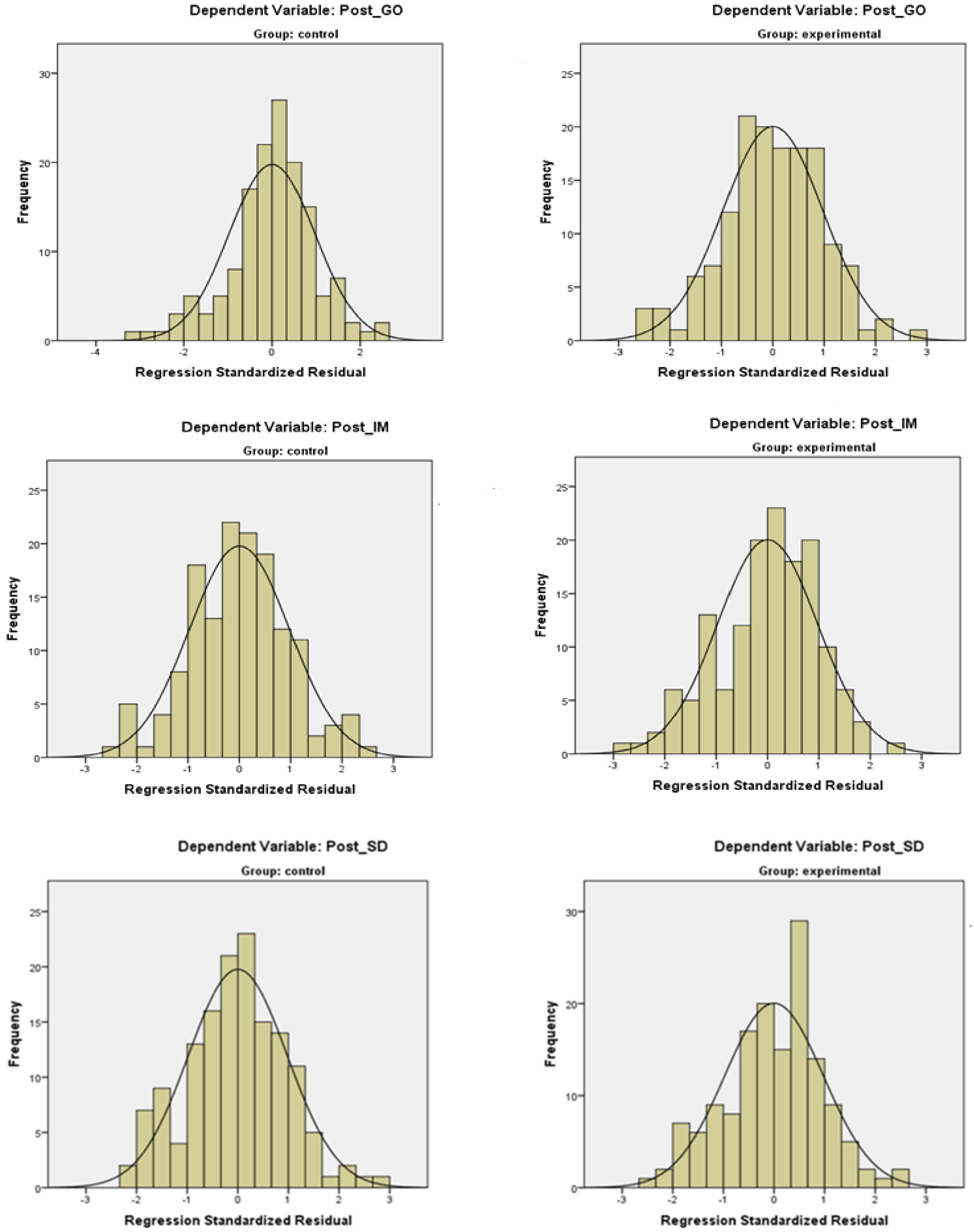

Figure 4.8 Histograms of the residuals in terms of groups (continued)

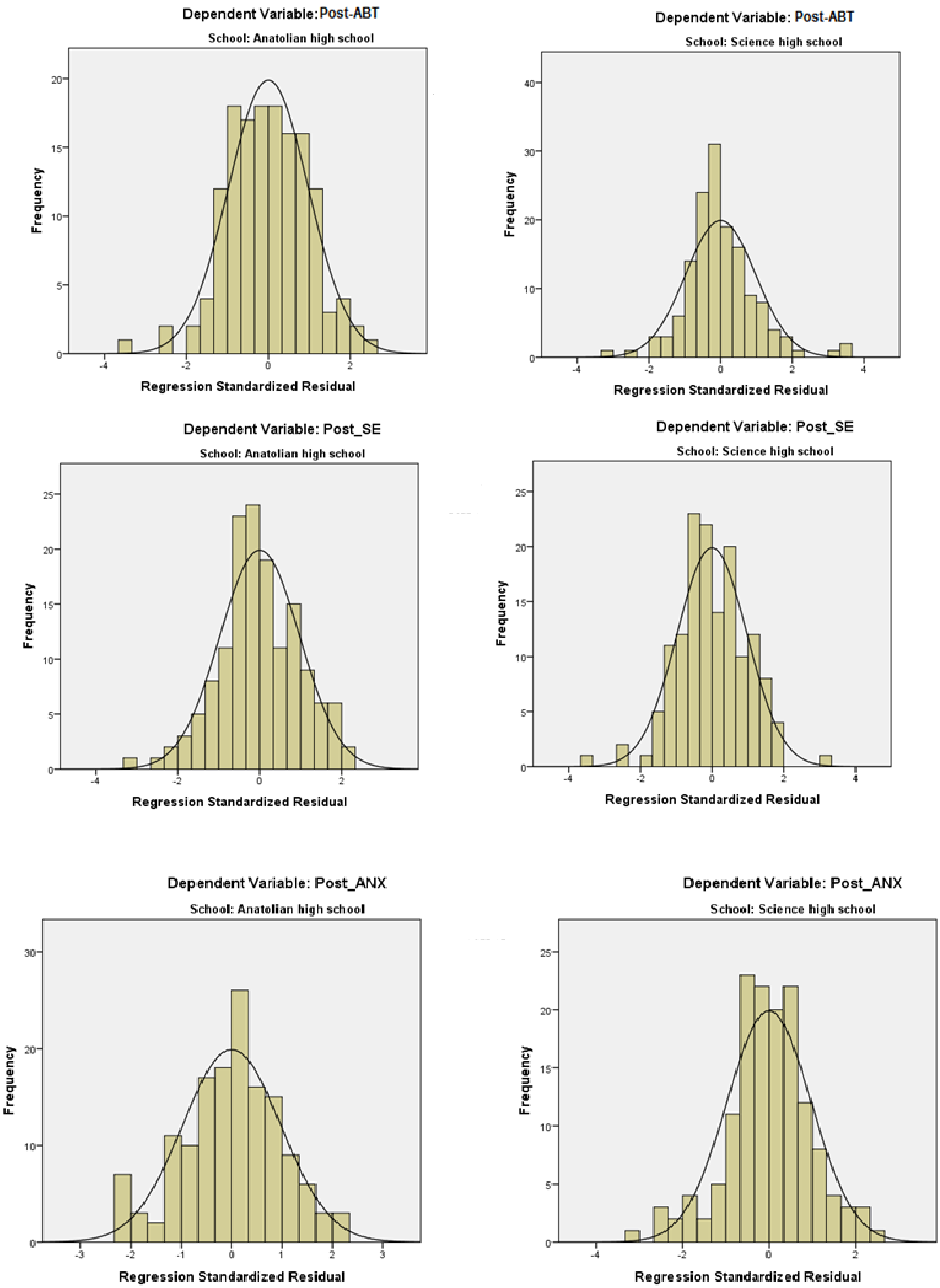

Figure 4.9 Histograms of the residuals in terms of schools

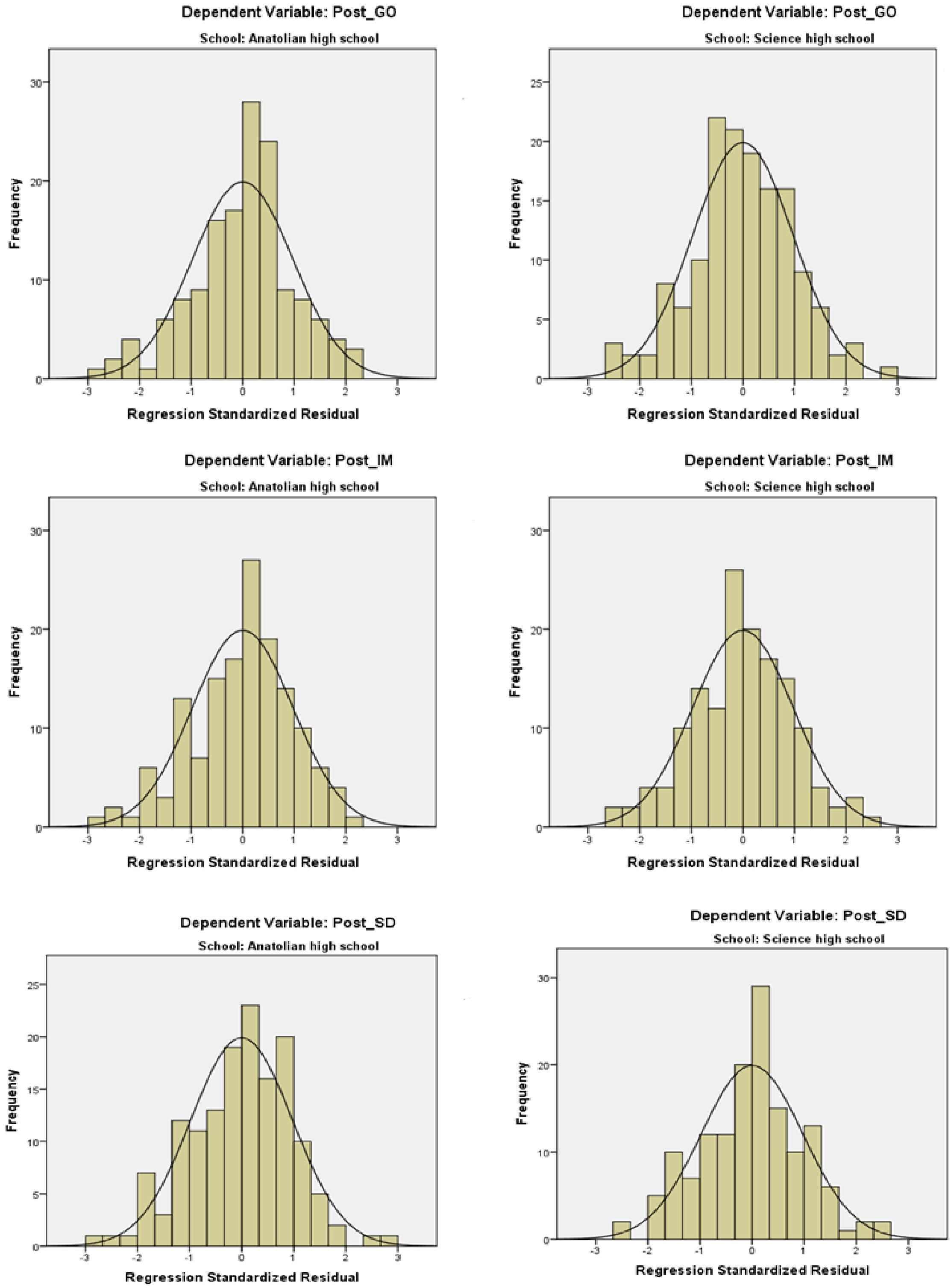

Figure 4.9 Histograms of the residuals in terms of schools (continued)

According to the histograms for each independent variable, all dependent variables may be accepted as normally distributed when the independent variables that are covariates of the study were put into the analysis as a set of variables next to school or group variable according to the selection of the data to be split in terms of school or group independent variable. Thus, the normality assumption was met.

4.3.1.2.7 Multicollinearity

When there is high correlation between dependent variables, which is above 0.9 according to Tabachnick & Fidell (2013), one dependent variable becomes a near-linear combination of the other dependent variables. Under such circumstances, it would become statistically redundant and suspect to include both combinations (French et al, 2002). For this reason, MANCOVA assumes there is no multicollinearity between dependent variables. In order to check the assumption, correlations between the dependent variables were analyzed by both correlation analysis and by linear regression of SPSS. In Table 4.20, correlation analysis results were given:

Table 4.20 Analysis of multicollinearity by correlation analysis

		Post-ABT	Post-SE	Post-ANX	Post-GO	Post-IM	Post-SD
Post-ABT	Pearson Correlation	1	,214**	,080	,273**	,232**	,172**
Post-SE	Pearson Correlation	,214**	1	,398**	,520**	,606**	,439**
Post-ANX	Pearson Correlation	,080	,398**	1	,349**	,315**	,266**
Post-GO	Pearson Correlation	,273**	,520**	,349**	1	,609**	,442**
Post-IM	Pearson Correlation	,232**	,606**	,315**	,609**	1	,405**
Post-SD	Pearson Correlation	,172**	,439**	,266**	,442**	,405**	1

Ideally it was okay to have up to moderate correlations between the dependent variables of the study in order to be protected from the multicollinearity. In Table 4.20, as it could be seen from the correlations between dependent variables, the correlations were mainly small up to moderate. So it is said that the multicollinearity assumption was met. In Table 4.21, the linear regression results were given for a double check:

Table 4.21 Analysis of multicollinearity by regression analysis

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	Post_SE	,541	1,847
	Post_ANX	,810	1,234
	Post_GO	,554	1,806
	Post_IM	,510	1,961
	Post_SD	,737	1,357

a. Dependent Variable: Post_ABAT

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	Post_ANX	,850	1,176
	Post_GO	,551	1,814
	Post_IM	,594	1,684
	Post_SD	,765	1,308
	Post_ABAT	,916	1,092

a. Dependent Variable: Post_SE

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	Post_GO	,553	1,809
	Post_IM	,509	1,965
	Post_SD	,739	1,354
	Post_ABAT	,915	1,093
	Post_SE	,567	1,762

a. Dependent Variable: Post_ANX

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	Post_IM	,596	1,677
	Post_SD	,767	1,304
	Post_ABAT	,933	1,071
	Post_SE	,549	1,820
	Post_ANX	,825	1,212

a. Dependent Variable: Post_GO

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	Post_SD	,741	1,350
	Post_ABAT	,915	1,093
	Post_SE	,630	1,587
	Post_ANX	,809	1,236
	Post_GO	,635	1,575

a. Dependent Variable: Post_IM

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	Post_ABAT	,914	1,094
	Post_SE	,561	1,783
	Post_ANX	,812	1,232
	Post_GO	,564	1,772
	Post_IM	,512	1,953

a. Dependent Variable: Post_SD

The same result could be said according to the regression analysis results (see table 4.21). The “VIF values” were checked to understand if there was multicollinearity. Authorities differ on how high the VIF has to be to constitute a problem. But mainly it was good when VIF value was smaller than 2.5 (Allison, 2012) as an evidence of no multicollinearity to be in the study. In between all the dependent variables, it was seen that there were not any VIF value larger than 2, 5. So, as it could be seen from the analysis, there were not any multicollinearity problems in the data. Which also means this assumption was also met.

4.3.1.2.8 Linearity

When two or more continuous variables were included in parametric statistics, it was assumed to have linearity between pairs of continuous variables according to Tabachnick and Fidell (2001). The assumption of linearity accepted that there were linear relationships among all pairs of dependent variables, all pairs of covariates, and all dependent variable-covariate pairs in each cell. If the variables are not linearly related, the power of the test is reduced (Tabachnick & Fidell, 2001) which is not wanted and according to Stevens (2002), this may cause improper adjusted means. Linearity assumption should be validated with graphical methods (Tabachnick & Fidell, 2001). In this study, in order to check this assumption, a scatterplot matrix between each pair of dependent variables, each pair of covariates and dependent variable-covariate pairs in each-cell conducted by splitting the data. Figure 4.10 shows all covariates and all dependent variables, Figure 4.11 shows all covariates in terms of groups; Figure 4.12 shows all the dependent variables in terms of groups whereas Figure 4.13 shows the dependent variable –covariate pairs in terms of groups. Moreover, Figure 4.14 shows all covariates in terms of schools, Figure 4.15 shows all the dependent variables in terms of schools whereas Figure 4.16 shows the dependent variable –covariate pairs in terms of schools.

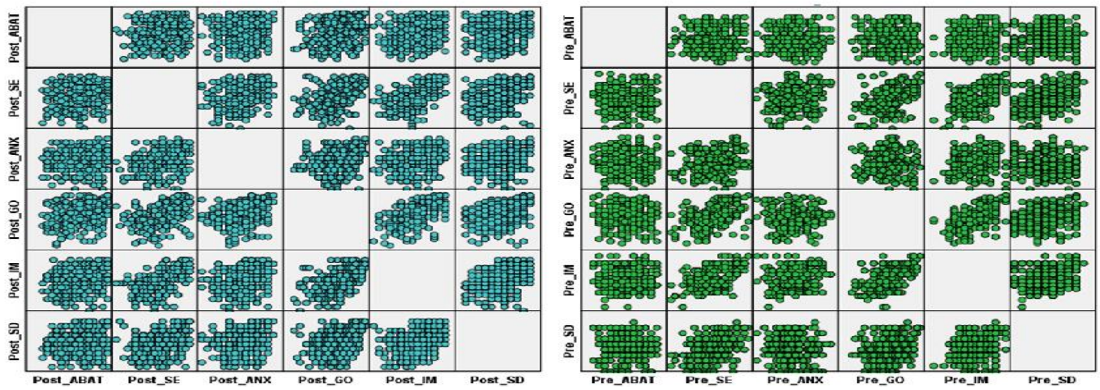

Figure 4.10 Scatter plots that show linearity for all pairs of dependent variables, all pairs of covariates

According to the scatter plots, all relations between dependent variables with each other and covariates with each other could be accepted as linear where as their strength were changing. For all pairs of dependent variables, the most linear relationships seen between post-SE and post-GO, post-SE and post-IM, post-SE and post-SD, post-ANX and post-GO, post-GO and post-IM, post-GO and post-SD, post-IM and post-SD. For all pairs of covariates, the most linear relationships were seen between post-SE and post-GO, post-SE and post-IM, post-SE and post-SD and post-GO and post-IM.

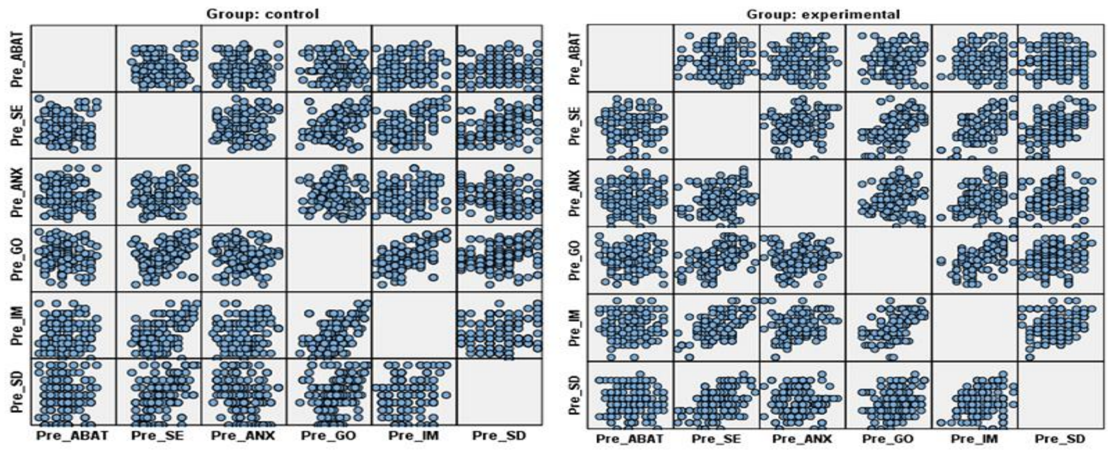

Figure 4.11 Scatter plots that show linearity for all the covariates in terms of groups

For group independent variable, according to the scatterplots, all relations between covariates with each other could be accepted as linear for both groups whereas their strength was changing. According to the scatterplots, a close linear relationship is seen mainly between pre-SE and pre-SD, pre-GO and pre-SE, pre-GO and pre-IM, pre-IM and pre-SE for the control group and for the experimental group it is seen between pre-SE and pre-GO, pre-SE and pre-IM, pre-SE and pre-SD, Pre-GO and pre-IM, Pre-IM and pre-SD.

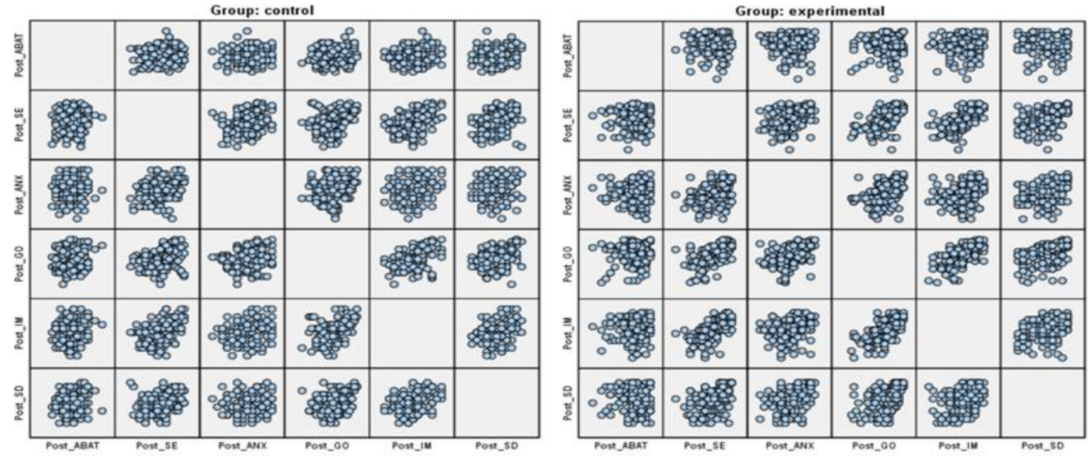

Figure 4.12 Scatter plots that show linearity for all the dependent variables in terms of groups

Again, for group independent variable, according to the scatterplots, all relations between dependent variables with each other could be accepted as linear for both groups whereas their strength was changing. According to the scatterplots, a more linear relationship is seen mainly between post-SE and post-ANX, post-SE and post-GO, post-SE and post-IM, post-SE and post-SD, post-GO and post-ANX, post-GO and post-IM, post-GO and post-SD, Post-IM and post-SD for the control group and for the experimental group it is seen between post-SE and post-ANX, post-SE and post-GO, post-SE and post-IM, post-SE and post-SD, post-ANX and post-GO, post-GO and post-ANX, post-GO and post-IM, post-GO and post-SD, post-IM and post-SD.

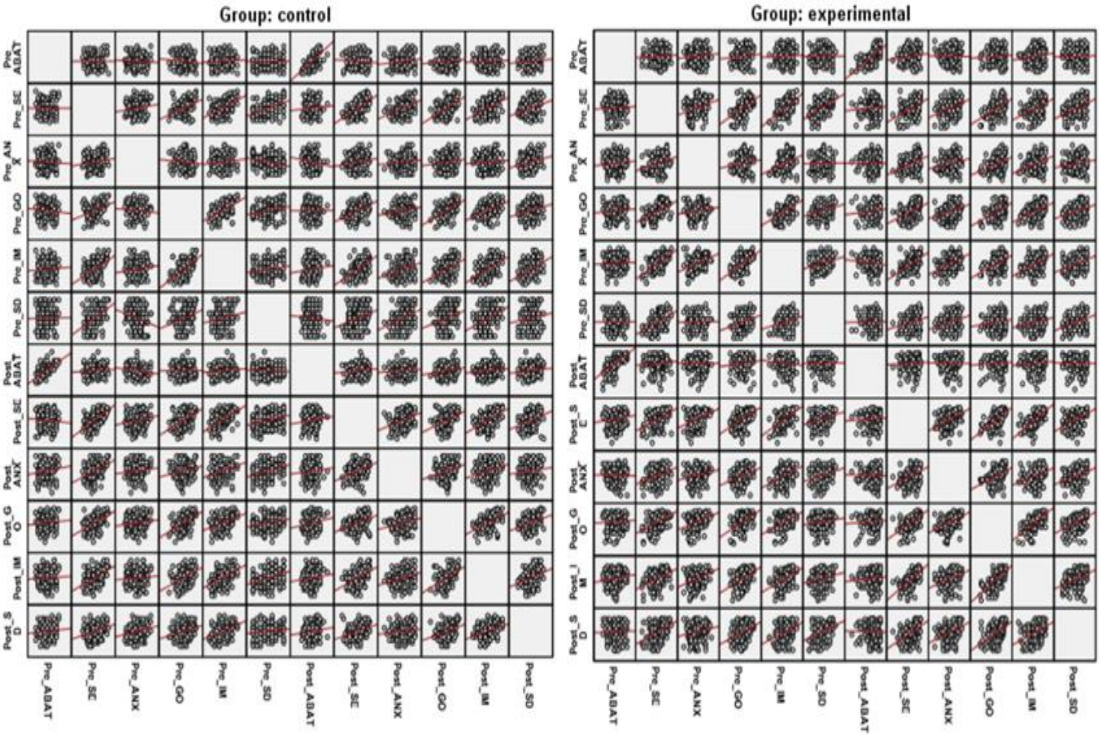

Figure 4.13 Scatter plots that show linearity for all dependent variable - covariate pairs in terms of groups

When the Figure 4.13 was examined, it was difficult to analyze the linear relations since there were many dependent variables and covariates in this study. Thus, for better understanding, the fit line which was linear was drawn for each variable in both groups. According to the results from the given figure, it might be seen that again all dependent variable-covariate pairs in both groups show linearity with different strengths. Thus, for the group variable, linearity assumption was said to be validated.

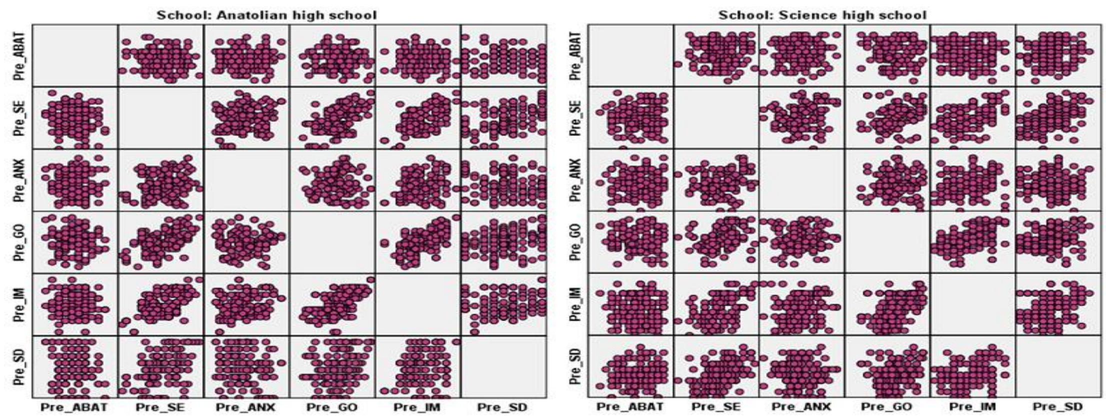

Figure 4.14 Scatter plots that show linearity for all the covariates in terms of school

For the school independent variable, according to the scatterplots, all relations between covariates with each other could be accepted as linear for both schools whereas their strength was changing. A close linear relationship is seen mainly between pre-SE and pre-GO, pre-SE and pre-IM, pre-SE and pre-SD, pre-GO and pre-IM for the Anatolian high school and it is seen between pre-SE and pre-GO, pre-SE and pre-IM, pre-SE and pre-SD, pre-GO and pre-IM, pre-GO and pre-SD, pre-IM and pre-SD.

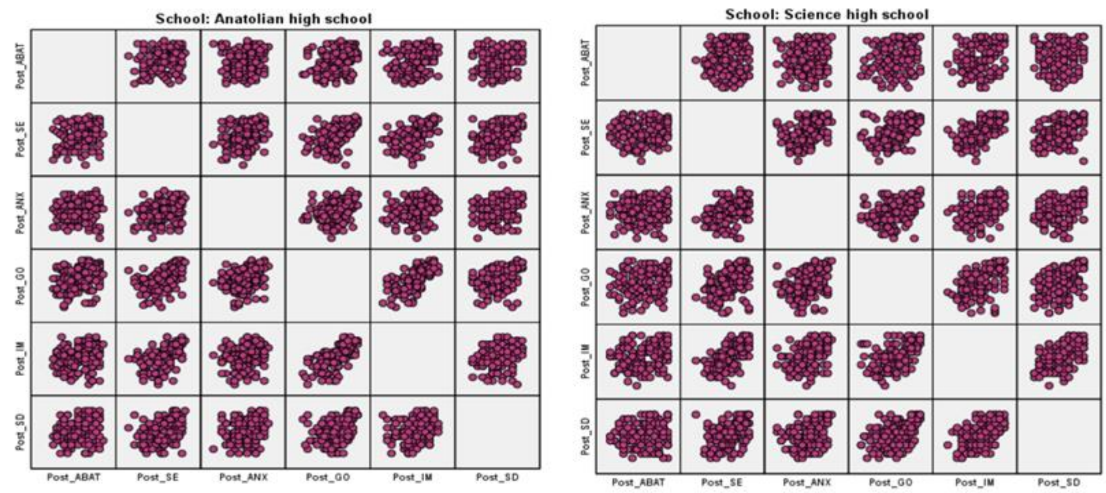

Figure 4.15 Scatter plots that show linearity for all dependent variables in terms of school

For school independent variable, according to the scatterplots, all relations between dependent variables with each other could be accepted as linear for both schools whereas their strength was changing. According to the scatterplots, a more linear relationship is seen mainly between post-SE and post-ANX, post-SE and post-GO, post-SE and post-IM, post-SE and post-SD, post-ANX and post-GO, post-GO and post-IM, post-GO and post-SD, Post-IM and post-SD for the control group and for the experimental group it is seen between post-SE and post-ANX, post-SE and post-GO, post-SE and post-IM, post-SE and post-SD, post-ANX and post-GO, post-ANX and post-IM, post-ANX and post-SD, post-GO and post-IM, post-GO and post-SD, post-IM and post-SD.

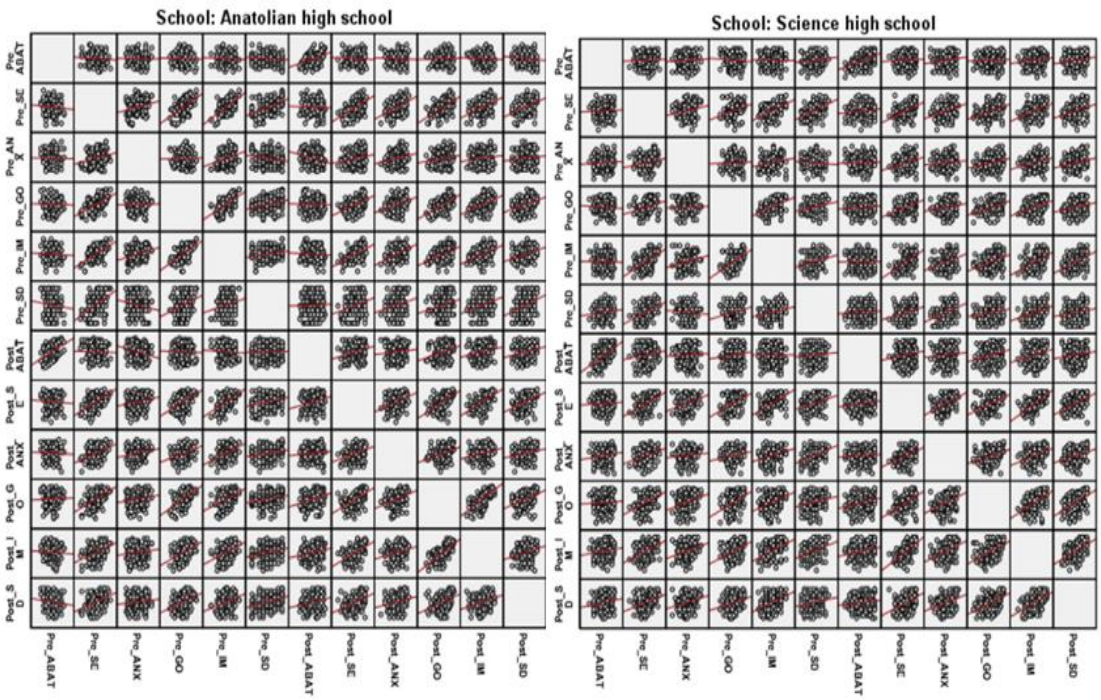

Figure 4.16 Scatter plots that show linearity for all dependent variable - covariate pairs in terms of school

When the Figure 4.16 was examined, it was difficult to analyze the linear relations since there were many dependent variables and covariates in this study so that they were not seen. Thus, for better understanding, the fit line which was linear was drawn for each variable in both groups. According to the results from the given figure, it might be seen that all dependent variable-covariate pairs in both schools show linearity with different strengths again. Thus, for the school variable, linearity assumption was said to be validated.

To make a conclusion, according to the scatter plots, there found to be weak relations between some of the variables in terms of group and school independent variables separately which also may lower the power of the study. However, all of these relationships were linear so that the MANCOVA analysis should still be applied in this study.

4.3.1.2.9 Homogeneity of Regression

Homogeneity of regression assumption checks for the relationship between the independent variables and covariates in terms of each group by custom analysis. Since the expected result is having no relationship between independent variable and the covariates, there should be insignificant results for the covariates. Table 4.22 shows the results:

Table 4.22 Multivariate test of homogeneity of regression for the interaction between the independent variable and covariates for each group

Effect		Value	F	Hypothesis df	Sig.
GRP * SCH	Pillai's Trace	,016	,689	6	,659
	Wilks' Lambda	,984	,689	6	,659
	Hotelling's Trace	,016	,689	6	,659
	Roy's Largest Root	,016	,689	6	,659
GRP * Pre-ABT	Pillai's Trace	,049	2,207	6	,053
	Wilks' Lambda	,951	2,207	6	,053
	Hotelling's Trace	,051	2,207	6	,053
	Roy's Largest Root	,051	2,207	6	,053
GRP * Pre-SE	Pillai's Trace	,042	1,879	6	,085
	Wilks' Lambda	,958	1,879	6	,085
	Hotelling's Trace	,044	1,879	6	,085
	Roy's Largest Root	,044	1,879	6	,085
GRP * Pre-ANX	Pillai's Trace	,028	1,265	6	,274
	Wilks' Lambda	,972	1,265	6	,274
	Hotelling's Trace	,029	1,265	6	,274
	Roy's Largest Root	,029	1,265	6	,274
GRP * Pre-GO	Pillai's Trace	,017	,750	6	,610
	Wilks' Lambda	,983	,750	6	,610
	Hotelling's Trace	,017	,750	6	,610
	Roy's Largest Root	,017	,750	6	,610
GRP * Pre-IM	Pillai's Trace	,043	1,920	6	,078
	Wilks' Lambda	,957	1,920	6	,078
	Hotelling's Trace	,044	1,920	6	,078
	Roy's Largest Root	,044	1,920	6	,078
GRP * Pre-SD	Pillai's Trace	,030	1,338	6	,241
	Wilks' Lambda	,970	1,338	6	,241
	Hotelling's Trace	,031	1,338	6	,241
	Roy's Largest Root	,031	1,338	6	,241

Table 4.22 Multivariate test of homogeneity of regression for the interaction between the independent variable and covariates for each group (continued)

Effect	Value	F	Hypothesis df	Sig.	Effect
SCH * Pre-ABT	Pillai's Trace	,035	1,572	6	,156
	Wilks' Lambda	,965	1,572	6	,156
	Hotelling's Trace	,036	1,572	6	,156
	Roy's Largest Root	,036	1,572	6	,156
SCH * Pre-SE	Pillai's Trace	,016	,711	6	,641
	Wilks' Lambda	,984	,711	6	,641
	Hotelling's Trace	,016	,711	6	,641
	Roy's Largest Root	,016	,711	6	,641
SCH * Pre-ANX	Pillai's Trace	,015	,643	6	,696
	Wilks' Lambda	,985	,643	6	,696
	Hotelling's Trace	,015	,643	6	,696
	Roy's Largest Root	,015	,643	6	,696
SCH * Pre-GO	Pillai's Trace	,032	1,438	6	,200
	Wilks' Lambda	,968	1,438	6	,200
	Hotelling's Trace	,033	1,438	6	,200
	Roy's Largest Root	,033	1,438	6	,200
SCH * Pre-IM	Pillai's Trace	,030	1,333	6	,243
	Wilks' Lambda	,970	1,333	6	,243
	Hotelling's Trace	,031	1,333	6	,243
	Roy's Largest Root	,031	1,333	6	,243
SCH * Pre-SD	Pillai's Trace	,034	1,498	6	,179
	Wilks' Lambda	,966	1,498	6	,179
	Hotelling's Trace	,035	1,498	6	,179
	Roy's Largest Root	,035	1,498	6	,179

Table 4.22 Multivariate test of homogeneity of regression for the interaction between the independent variable and covariates for each group (continued)

Effect	Value	F	Hypothesis df	Sig.	Effect
GRP * SCH * Pre-ABT	Pillai's Trace	,008	,329	6	,921
	Wilks' Lambda	,992	,329	6	,921
	Hotelling's Trace	,008	,329	6	,921
	Roy's Largest Root	,008	,329	6	,921
GRP * SCH * Pre-SE	Pillai's Trace	,009	,405	6	,875
	Wilks' Lambda	,991	,405	6	,875
	Hotelling's Trace	,009	,405	6	,875
	Roy's Largest Root	,009	,405	6	,875
GRP * SCH * Pre-ANX	Pillai's Trace	,009	,384	6	,889
	Wilks' Lambda	,991	,384	6	,889
	Hotelling's Trace	,009	,384	6	,889
	Roy's Largest Root	,009	,384	6	,889
GRP * SCH * Pre-GO	Pillai's Trace	,020	,871	6	,517
	Wilks' Lambda	,980	,871	6	,517
	Hotelling's Trace	,020	,871	6	,517
	Roy's Largest Root	,020	,871	6	,517
GRP * SCH * Pre-IM	Pillai's Trace	,024	1,052	6	,392
	Wilks' Lambda	,976	1,052	6	,392
	Hotelling's Trace	,024	1,052	6	,392
	Roy's Largest Root	,024	1,052	6	,392
GRP * SCH * Pre-SD	Pillai's Trace	,027	1,211	6	,301
	Wilks' Lambda	,973	1,211	6	,301
	Hotelling's Trace	,028	1,211	6	,301
	Roy's Largest Root	,028	1,211	6	,301

According to Table 4.18, as it was expected, the relationship between the covariates and the independent variables were not significant for p= 0.05. So, the assumption is validated.

4.3.1.2.10 Homogeneity of Variance

There is homogeneity of variance matrice assumption to test the equality of variances of the study. It was again tested by using Box's M Test that was already given above (see Table 4.19). MANCOVA analysis makes the assumption that the within-group matrices are equal and in this study, one reason of selecting MANCOVA was also because of number of students in each of the group was approximately equal.

Since MANCOVA assumed that each dependent variable would have similar variances for all groups with the hypothesis of the variances in scores is the same for each group, Levene's test of homogeneity of variance could also be used to check this assumption. So, it was an additional check of the diagonals of the covariance matrices. In Levene’s test it was expected Levene statistics to be not significant at least at the level .05 so that, the null hypothesis that tests the groups to have equal variances could be rejected. Table 4.23 shows the result of Levene’s test and all values were found larger than 0.05, which indicated the error variances across groups were equal. Consequently, the assumption of homogeneity of variances was satisfied for each score.

Table 4.23 Levene’s test of homogeneity of variance

	F	df1	df2	Sig.
Post-ABT	1,073	3	288	,361
Post-SE	,294	3	288	,830
Post-ANX	,098	3	288	,961
Post-GO	1,728	3	288	,161
Post-IM	1,036	3	288	,377
Post-SD	1,907	3	288	,129

For these data, the homogeneity of variance was met for all dependent variables since for an alpha level 0.05, p was higher than the alpha for each dependent variables. In other words, each dependent variable had similar variances for all groups that the variances in scores were the same for each group.

4.3.1.3 Interpreting the MANCOVA Analysis Results

After the MANCOVA assumptions were met, the tables needed to be interpreted. This interpretation would be more meaningful when they were analyzed in terms of the main problem which was to investigate the effect of CBL instruction when compared to traditionally designed instruction and to investigate students' motivation to learn chemistry. The first table is the Multivariate tests table (see table 4.24) which simultaneously tests the factor effect on the dependent variables should be controlled:

Table 4.24 Multivariate tests results table

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Observed Power
Intercept	,172	9,584	6,000	277,0	,000	,172	1,000
Pre-ABT	,574	34,262	6,000	277,0	,000	,426	1,000
Pre-SE	,871	6,819	6,000	277,0	,000	,129	1,000
Pre-ANX	,824	9,876	6,000	277,0	,000	,176	1,000
Pre-GO	,779	13,097	6,000	277,0	,000	,221	1,000
Pre-IM	,888	5,802	6,000	277,0	,000	,112	,998
Pre-SD	,921	3,970	6,000	277,0	,001	,079	,970
Group	,350	85,78	6,000	277,0	,000	,650	1,000
School	,984	,738	6,000	277,0	,620	,016	,291
Group* School	,981	,896	6,000	277,0	,498	,019	,353

There were four different multivariate significance tests. But the most appropriate one to be used was the Wilks' Lambda. The significance of the F tests shows if the overall effect of the independent variable on the dependent variables and a significant *F* indicates that there are significant differences on a linear combination of the two dependent variables.

By the help of the Table 4.24, answers to the general questions "are the collective dependent variables significantly different across all groups/schools/group and school interaction together?" were answered. According to the significance given in Table 4.24, the results revealed that the collective dependent variables were significantly different across all groups but not across school or group and school together.

So, from the Table 4.24, it could be concluded that there was overall significance in terms of group independent variable since, Wilks' Lambda = 0.350, $F(6,277) = 85.782$, $p = 0.000$, $p < 0.05$ and partial eta squared (which is the estimates of the effect size) was equal to 0,65 which is a high effect size (Cohen, 1988). However, it was not significant for the school independent variable since, Wilks' Lambda=0.984, $F(6,277) = 0.738$, $p=0.620$, $p > 0.05$ and partial eta squared (which is the estimates of the effect size) was equal to 0,016 which was a small effect size (Cohen, 1988). It was also not significant for the group and school independent variables together (Wilks' Lambda=0.981, $F(6,277) = 0.896$, $p=0.498$, $p > 0.05$) and partial eta squared (which is the estimates of the effect size) was equal to 0.019 which was a small effect size (Cohen, 1988).

In addition to these, as it was known, the significance level of a test equals to the rate of type I error and power is related to the rate of the type II error. For reducing these errors, the power of the test needed to be higher than 0.9 and in this study it was provided for only the group independent variable since it equals to 1.00.

After obtaining a significant multivariate test for the particular main effects and they were analyzed, the table that could also be taken into consideration was the "Tests of Between-Subjects Effects" table (see Table 4.25) to determine how the dependent variables which were the students' understanding of acids and bases concepts and their motivation to learn chemistry differ for the school and group independent variables when the related covariates of the study were controlled. In other words, by conducting this analysis, the results would be checked whether only the group or school affected the students' acids and bases concepts and their motivation to learn chemistry or if one them affected, then which group or school affected these study results according to students' understanding of acids and bases concepts and their motivation to learn chemistry or if they affected the study results all together. The output of this table gave the univariate ANCOVA effects for the factor. The "corrected model" effect reflects the variation in the dependent attributed to other effects in the model, after corrected by the mean:

Table 4.25 Tests of between subjects effects table

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Corrected Model	Post-ABT	24958,215	9	2773,135	83,780	,000	,728	1,000
	Post-SE	2434,578	9	270,509	25,867	,000	,452	1,000
	Post-ANX	491,849	9	54,650	8,941	,000	,222	1,000
	Post-GO	3202,516	9	355,835	23,632	,000	,430	1,000
	Post-IM	875,755	9	97,306	18,129	,000	,367	1,000
	Post-SD	504,230	9	56,026	10,837	,000	,257	1,000

Table 4.25 Tests of between subjects effects table (continued)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Intercept	Post-ABT	2211,099	1	2211,099	66,800	,000	,192	1,000
	Post-SE	66,272	1	66,272	6,337	,012	,022	,708
	Post-ANX	27,364	1	27,364	4,477	,035	,016	,559
	Post-GO	1,658	1	1,658	,110	,740	,000	,063
	Post-IM	13,043	1	13,043	2,430	,120	,009	,342
	Post-SD	71,722	1	71,722	13,873	,000	,047	,960

Table 4.25 Tests of between subjects effects table (continued)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Pre-ABT	Post-ABT	6437,096	1	6437,096	194,473	,000	,408	1,000
	Post-SE	2,207	1	2,207	,211	,646	,001	,074
	Post-ANX	11,101	1	11,101	1,816	,179	,006	,269
	Post-GO	21,004	1	21,004	1,395	,239	,005	,218
	Post-IM	9,014	1	9,014	1,679	,196	,006	,252
	Post-SD	5,608	1	5,608	1,085	,299	,004	,180

Table 4.25 Tests of between subjects effects table (continued)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Pre-SE	Post-ABT	268,768	1	268,768	8,120	,005	,028	,811
	Post-SE	140,933	1	140,933	13,476	,000	,046	,955
	Post-ANX	24,518	1	24,518	4,011	,046	,014	,514
	Post-GO	333,219	1	333,219	22,130	,000	,073	,997
	Post-IM	21,370	1	21,370	3,981	,047	,014	,511
	Post-SD	15,570	1	15,570	3,012	,084	,011	,409

Table 4.25 Tests of between subjects effects table (continued)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
	Post-ABT	184,143	1	184,143	5,563	,019	,019	,652
	Post-SE	116,820	1	116,820	11,171	,001	,038	,915
	Post-ANX	15,359	1	15,359	2,513	,004	,009	,352
Pre-ANX	Post-GO	159,220	1	159,220	10,574	,001	,036	,900
	Post-IM	48,043	1	48,043	8,951	,003	,031	,847
	Post-SD	28,382	1	28,382	5,490	,020	,019	,646

Table 4.25 Tests of between subjects effects table (continued)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Pre-GO	Post-ABT	89,355	1	89,355	2,700	,101	,009	,374
	Post-SE	138,454	1	138,454	13,239	,000	,045	,952
	Post-ANX	1,261	1	1,261	,206	,650	,001	,074
	Post-GO	623,258	1	623,258	41,392	,000	,128	1,000
	Post-IM	74,351	1	74,351	13,852	,000	,047	,960
	Post-SD	14,298	1	14,298	2,766	,097	,010	,381

Table 4.25 Tests of between subjects effects table (continued)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Pre-IM	Post-ABT	133,236	1	133,236	4,025	,046	,014	,516
	Post-SE	204,582	1	204,582	19,563	,000	,065	,993
	Post-ANX	61,578	1	61,578	10,075	,002	,034	,886
	Post-GO	1,632	1	1,632	,108	,742	,000	,062
	Post-IM	48,451	1	48,451	9,027	,003	,031	,849
	Post-SD	47,544	1	47,544	9,196	,003	,032	,856

Table 4.25 Tests of between subjects effects table (continued)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Pre-SD	Post-ABT	179,899	1	179,899	5,435	,020	,019	,642
	Post-SE	14,518	1	14,518	1,388	,240	,005	,217
	Post-ANX	49,929	1	49,929	8,169	,005	,028	,813
	Post-GO	5,255	1	5,255	,349	,555	,001	,091
	Post-IM	30,083	1	30,083	5,605	,019	,019	,655
	Post-SD	22,562	1	22,562	4,364	,038	,015	,549

Table 4.25 Tests of between subjects effects table (continued)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Group	Post-ABT	16592,623	1	16592,623	501,284	,000	,640	1,000
	Post-SE	264,633	1	264,633	25,305	,000	,082	,999
	Post-ANX	10,166	1	10,166	1,663	,000	,006	,251
	Post-GO	592,176	1	592,176	39,328	,000	,122	1,000
	Post-IM	125,277	1	125,277	23,340	,000	,076	,998
	Post-SD	74,231	1	74,231	14,359	,000	,048	,965

Table 4.25 Tests of between subjects effects table (continued)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
School	Post-ABT	31,274	1	31,274	,945	,332	,003	,162
	Post-SE	3,517	1	3,517	,336	,562	,001	,089
	Post-ANX	18,910	1	18,910	3,094	,080	,011	,418
	Post-GO	,418	1	,418	,028	,868	,000	,053
	Post-IM	1,175	1	1,175	,219	,640	,001	,075
	Post-SD	5,326	1	5,326	1,030	,311	,004	,173

Table 4.25 Tests of between subjects effects table (continued)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Group * School	Post-ABT	13,808	1	13,808	,417	,519	,001	,099
	Post-SE	56,254	1	56,254	5,379	,021	,019	,637
	Post-ANX	9,638	1	9,638	1,577	,210	,006	,240
	Post-GO	86,939	1	86,939	5,774	,017	,020	,668
	Post-IM	8,211	1	8,211	1,530	,217	,005	,234
	Post-SD	18,403	1	18,403	3,560	,060	,012	,468

Table 4.25 Tests of between subjects effects table (continued)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Error	Post-ABT	9334,278	282	33,100				
	Post-SE	2949,080	282	10,458				
	Post-ANX	1723,644	282	6,112				
	Post-GO	4246,169	282	15,057				
	Post-IM	1513,653	282	5,368				
	Post-SD	1457,889	282	5,170				

Table 4.25 Tests of between subjects effects table (continued)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
	Post-ABT	1992456,000	292					
	Post-SE	305032,000	292					
	Post-ANX	112004,000	292					
Total								
	Post-GO	211130,000	292					
	Post-IM	115893,000	292					
	Post-SD	123489,000	292					

Table 4.25 Tests of between subjects effects table (continued)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Corrected Total	Post-ABT	34292,493	291					
	Post-SE	5383,658	291					
	Post-ANX	2215,493	291					
	Post-GO	7448,685	291					
	Post-IM	2389,408	291					
	Post-SD	1962,120	291					

From the Table 4.25, it could be concluded that main effect of group on students' understanding ($F(1,282)= 501.284$, $p=0.000$, $p<0,05$ with the effect size=0.64), self-efficacy ($F(1,282)=25,305$, $p=0.000$, $p<0,05$ with the effect size=0.082), anxiety ($F(1,282)=1.663$, $p=0.000$, $p<0,05$ with the effect size=0.006), goal-orientation ($F(1,282)=39.328$, $p=0.000$, $p<0,05$ with the effect size=0.122), intrinsic motivation ($F(1,282)=23.340$, $p=0.000$, $p<0,05$ with the effect size=0.076) and self-determination ($F(1,282)=14.359$, $p=0.000$, $p<0,05$ with the effect size=0.048) were all significant. In other words, all univariate effects for "Group" independent variable were significant: the students being in the experimental or control group effect their understanding of acids and bases concepts and their motivation to learn chemistry.

For "school" independent variable, there were no univariate effects to be found as statistically significant. This shows that the school students were attending does not affect students' understanding and their motivation to learn chemistry as a whole.

For "group" and "school" independent variables affect together, post-SE (self-efficacy) and post-GO (goal-orientation) univariate effects, which were the constructs of students' motivation to learn chemistry, were significant. Thus, the main effect for "group" and "school" independent variables together on students' self-efficacy ($F(1,282)= 5.379$, $p=0.021$, $p<0,05$ with the effect size=0.019) and goal-orientation ($F(1,282)= 5.774$, $p=0.017$, $p<0,05$ with the effect size=0.020) were significant. In other words, it could be concluded that, students' being in the control group or in the experimental group together with the type of school they attend does not affect their understanding of acids and bases concepts but their self-efficacy and goal-orientation that were the constructs of motivation.

Moreover, when the pre-test and post-test were separately analyzed there were additional results found accordingly. First of all, the pre-ABT test scores had a significant effect on the post-ABT scores of the students. In other words, students' pre-ABT scores affected students' post-ABT scores. Second of all, the pre-SE scores had a significant effect on students' post-ABT, post-SE, post-ANX, post-GO and post-IM scores. In other words, students' self-efficacy before the implementation affected students' understanding, self-efficacy, anxiety, goal-orientation and intrinsic motivation after the implementation. Third of all, the pre-ANX scores affected students' post-ABT, post-SE, post-ANX, post-GO, post-IM and post-SD. In other words, students' anxiety before the implementation affected students' understanding of acids and bases concepts, their self-efficacy, anxiety, goal-orientation, intrinsic motivation and self-determination after the implementation. Fourth of all, the pre-GO scores had a significant effect on students' post-SE, post-GO and post-IM. In other words, students' goal-orientation before the implementation affected their self-efficacy, goal-orientation and intrinsic motivation after the implementation. Fifth of all, the pre-IM scores of the students had a significant effect on post-ABT, post-SE, post-ANX, post-IM and post-SD scores of the students. In other words, students' intrinsic motivation before the study affected their understanding of acids and bases concepts, their self-efficacy, anxiety, intrinsic motivation and self-determination after the implementation. Sixth of all, the pre-SD scores of the students had a significant effect on students' post-ANX, post-IM and post-SD. In other words, students' self-determination before the implementation affected their anxiety, intrinsic motivation and self-determination after the implementation.

As it is known, MANCOVA also has the analysis for the comparing the main effects with Bonferroni Test. Thus, these tests were also done and the pairwise comparisons were checked. In Tables 4.26 and in Table 4.27 the pairwise comparison tables for group and school independent variables were given in order:

Table 4.26 Pairwise comparison in terms of group independent variable

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	S.E.	Sig.
Post-ABT	Control	Experimental	-15,171*	,678	,000
	Experimental	Control	15,171*	,678	,000
Post-SE	Control	Experimental	-1,916*	,381	,000
	Experimental	Control	1,916*	,381	,000
Post-ANX	Control	Experimental	-,376	,291	,008
	Experimental	Control	,376	,291	,008
Post-GO	Control	Experimental	-2,866*	,457	,000
	Experimental	Control	2,866*	,457	,000
Post-IM	Control	Experimental	-1,318*	,273	,000
	Experimental	Control	1,318*	,273	,000
Post-SD	Control	Experimental	-1,015*	,268	,000
	Experimental	Control	1,015*	,268	,000

The table above (Table 4.26) shows that for the mean scores of students' understanding of acids and bases concepts next to their self-efficacy, goal-orientation, intrinsic motivation and self-determination constructs of motivation were statistically significantly different between control and experimental group ($p < .05$) in the favor of experimental group.

Table 4.27 Pairwise comparison in terms of school independent variable

Dependent Variable	(I) School	(J) School	Mean Difference (I-J)	S.E.	Sig.[a]
Post-ABT	Anatolian high school	Science high school	,744	,766	,332
	Science high school	Anatolian high school	-,744	,766	,332
Post-SE	Anatolian high school	Science high school	,250	,430	,562
	Science high school	Anatolian high school	-,250	,430	,562
Post-ANX	Anatolian high school	Science high school	,579	,329	,080
	Science high school	Anatolian high school	-,579	,329	,080
Post-GO	Anatolian high school	Science high school	,086	,516	,868
	Science high school	Anatolian high school	-,086	,516	,868
Post-IM	Anatolian high school	Science high school	-,144	,308	,640
	Science high school	Anatolian high school	,144	,308	,640
Post-SD	Anatolian high school	Science high school	,307	,303	,311
	Science high school	Anatolian high school	-,307	,303	,311

The table above (Table 4.27) shows that for the mean scores of students' understanding of acids and bases concepts next to their self-efficacy, anxiety, goal-orientation, intrinsic motivation and self-determination constructs of motivation were not statistically significantly different between Anatolian and science high schools ($p > 0 .05$). However, even if there was nearly no mean difference between the types of the schools, a small difference could be observed in the favor of Anatolian high school for many variables (except intrinsic motivation) that were not statistically significant.

To conclude, according to the results of the analysis as mentioned above, in terms of group independent variable, the experimental group scores were higher than the control groups scores in terms of each dependent variable. But when it came to the school independent variable, for students' understanding of acids and bases concepts, self-efficacy, anxiety, goal-orientation and self-determination; Anatolian high school's mean scores seem a bit higher than the science high school mean scores. For only intrinsic motivation, science high school's mean scores seemed a bit higher than the Anatolian high school. Thus, in terms of school independent variable, students being attending to science or Anatolian high school found to be ineffective on students' understanding and their motivation as a whole.

From now on, the hypothesis of the study should be tested with additional analysis (follow-up ANCOVAs) as a double check to this study results next to the significant results collected from the MANCOVA analysis.

4.3.2 Follow up ANCOVA Analysis

By conducting follow-up ANCOVA's, the univariate F tests for each variable to interpret the respective effect might be examined. In other words the specific dependent variables that contributed to the significant overall effect could be identified next to the MANCOVA results. To collect evidences for the main problem, in this part, the following null hypothesis would be studied:

4.3.2.1 Null Hypothesis 1

The first null hypothesis to check is "there is no statistically significant difference between teaching methods when taking CBL and traditionally designed instruction into account on the population mean of the collective dependent variables of eleventh grade students' post-test scores of Acids and Bases Test (post-ABT) and motivation to learn chemistry post-test scores of each construct (post-CMQ constructs) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

In order to test this hypothesis, the Table 4.24 from MANCOVA analysis should be used. Based on the results of the Table 4.24, the null hypothesis was rejected so that it was accepted to have a statistically significant difference between the CBL and traditionally designed instruction on the related collective dependent variables since; for the alpha level 0.05, *Wilks' Λ* = 0.35, *F* (6, 277) = 85,782, p=0.00. Multivariate η^2 = .65 that indicates a large effect size (Cohen, 1988). In addition to that, this value indicates, approximately 65% of multivariate variance of the dependent variable was associated with the group factor.

According to table 4.24, it was revealed that the students taught with CBL instruction had statistically significant effect on the collective dependent variables when compared to traditionally designed instruction.

4.3.2.2 Null Hypothesis 2

The second null hypothesis is "there is no statistically significant mean difference between Anatolian and science high schools on the population means of the collective dependent variables of eleventh grade students' post-test scores of Acids and Bases Test (post-ABT) and motivation to learn chemistry post-test scores of each construct (post-CMQ constructs) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

According to the MANCOVA analysis results given in Table 24, it was revealed that the null hypothesis was accepted since p = 0.62. Thus, it could be said that, there wasn't any significant difference between Anatolian and science high schools on the related collective dependent variables for the alpha level 0.05 (*Wilk's Λ* = 0.984, *F* (6, 277) = 0.738).

So, it might also be concluded that the students attending both schools had nearly equal understanding of acids and bases unit of chemistry and their motivation to learn chemistry is also very close to each other, regardless teaching method.

4.3.2.3 Null Hypothesis 3

The third null hypothesis is "there is no statistically significant interaction between the treatment and school types on the population means of collective dependent variables of eleventh grade students' post-test scores of Acids and Bases Test (post-ABT) and motivation to learn chemistry post-test scores of each construct (post-CMQ constructs) and motivation to learn chemistry post-test scores of each construct when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.

According to the MANCOVA analysis results given in Table 4.24, the null hypothesis was accepted since p = 0.498. So, there was no statistically significant interaction between the methods and schools for the related dependent variables. In other words, it was found that, the methods for acid base unit of chemistry and schools that the eleventh grade students attend on the population means of collective dependent variables of the post-tests' scores for the alpha level 0.05 (*Wilks' Λ* = 0.981, *F* (6, 277) = 0.896, p=0.498).

So, it could also be concluded that CBL instruction makes no difference for the Anatolian and science high school students in the understanding of acid base unit or students' motivation over traditional instruction.

4.3.2.4 Null Hypothesis 4

The fourth null hypothesis is "there is no statistically significant difference between the students taught via CBL instruction and traditionally designed instruction on the population means of the post-test scores of Acids and Bases Test (post-ABT) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

In order to test the hypothesis, a follow-up ANCOVA was conducted so that the effect of teaching methods should be analyzed on the post-test scores of the ABT (stated dependent variable). Table 4.28 shows the results:

Table 4.28 Follow-up ANCOVA for post-ABT dependent variable

Source	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Corrected Model	9	2773,135	83,780	,000	,728	1,000
Intercept	1	2211,099	66,800	,000	,192	1,000
Pre-ABT	1	6437,096	194,473	,000	,408	1,000
Pre-SE	1	268,768	8,120	,005	,028	,811
Pre-ANX	1	184,143	5,563	,019	,019	,652
Pre-GO	1	89,355	2,700	,101	,009	,374
Pre-IM	1	133,236	4,025	,046	,014	,516
Pre-SD	1	179,899	5,435	,020	,019	,642
Group	1	16592,623	501,284	,000	,640	1,000
School	1	31,274	,945	,332	,003	,162
Group * School	1	13,808	,417	,519	,001	,099
Error	282	33,100				
Total	292					
Corrected Total	291					

According to the results from Table 4.28, the null hypothesis was rejected so, for the alpha level 0.05, it could be concluded that there was a significant difference between the students' understanding of acids and bases concepts in terms of CBL and traditionally designed instruction since F (1,282) = 501.284, p = 0.00 in the favor of CBL instruction (experimental group) since in table 4.5 the post-ABT mean test scores of students that were taught with CBL was 89,4422 whereas ABT mean scores of the students that were taught with traditionally designed method was 74,2345 which was found to be statistically significant by the follow-up ANCOVA analysis.

Another finding from this analysis was that, the partial eta squared came out as 0.64 which was equal to the high effect size according to Tabachnick & Fidell (2001). In other words, the treatment accounts for 64% variability in student understanding of acids and bases unit of chemistry while the power to detect the effect was 1.000. In order to observe the effects of the covariates, Table 4.29 was given that includes estimated mean scores:

Table 4.29 Estimated marginal means for the post-ABT in terms of groups

Group	Mean	Mean Difference (I-J)	S.E.
Control	74,249[a]	-15,171*	,479
Experimental	89,419[a]	15,171*	,476

According to Table 4.29, the mean difference between experimental group (CBL Instructed group) and control group (traditionally designed instruction) was 15.171. But in reality these difference was 15.2077 (check from table 4.5). The difference occurred because of the adjustment of the mean with the covariate.

4.3.2.5 Null Hypothesis 5

The fifth null hypothesis is “there is no statistically significant difference between Anatolian and science high school on the population means of the post-test scores of Acids and Bases Test (post-ABT) when the effects of students’ previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.”

In order to analyze this hypothesis, Table 4.28 was applied and it was found that the null hypothesis could not be rejected since F (1,282) =0.945, p = 0.332. Therefore, it could be concluded that, the school type did not differ in understanding the acids and bases concepts. The implemented method for the experimental group did not make any significant difference on students’ understanding of acids and bases unit in terms of the school types they were attending. To see the covariates effect, again the estimated marginal means would be analyzed (see Table 4.30):

Table 4.30 Estimated marginal means for the post-ABT in terms of groups

School	Mean	Mean Difference (I-J)	S.E.
Anatolian high school	82,206[a]	-0.744	,510
Science high school	81,462[a]	0.744	,510

According to Table 4.30, the mean difference between experimental group (CBL Instructed group) and control group (traditionally designed instruction) was 0.744. But in reality these difference was 3.7124 (check from Table 4.7). The difference occurred by the adjustment of the mean with the covariate effect but it wasn't significant statistically since the null hypothesis was accepted.

4.3.2.6 Null Hypothesis 6

The sixth null hypothesis is "there is no statistically significant interaction between the treatment and school types on the population means of the post-test scores of Acids and Bases Test (post-ABT) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

In order to analyze the effect of interaction between methods of teaching, and school types for its significance, Table 4.28 could be checked for significance and a graph of estimated marginal means of post-ABT could be plotted (see Figure 4.17) for analyzing the post-ABT scores in terms of school types as categorized in treatment:

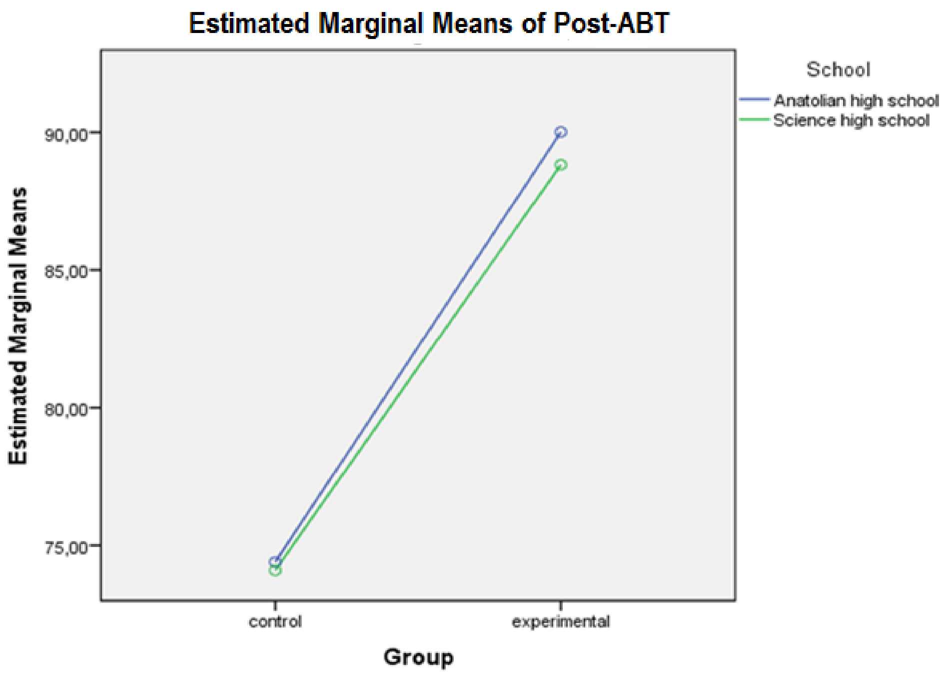

Figure 4.17 Graph of post-ABT scores in terms of school types as categorized in group

According to the performed follow-up ANCOVA investigated results (see Table 4.28), this null hypothesis was accepted since F (1,282) =0.417, p = 0.519. Therefore, it might be concluded that, there was not any interaction between methods of teaching and school types in understanding the acid base unit of chemistry. The implemented method for the experimental group did not make any significant difference on students' understanding of acids and bases unit in terms of the school types they were attending.

4.3.2.7 Null Hypothesis 7

The seventh null hypothesis is "there is no statistically significant difference between students taught via CBL instruction and traditionally designed instruction on the population means of the post-test scores of the self-efficacy construct of motivation to learn chemistry questionnaire (post-SE) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

For testing this null hypothesis, another follow-up ANCOVA was conducted by taking self-efficacy construct of motivation into account. Table 4.31 gives the related results of the analysis.

Table 4.31 Follow-up ANCOVA for post-SE dependent variable

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Corrected Model	2434,578[a]	9	270,509	25,867	,000	,452	1,000
Intercept	66,272	1	66,272	6,337	,012	,022	,708
Pre-ABT	2,207	1	2,207	,211	,646	,001	,074
Pre-SE	140,933	1	140,933	13,476	,000	,046	,955
Pre-ANX	116,820	1	116,820	11,171	,001	,038	,915
Pre-GO	138,454	1	138,454	13,239	,000	,045	,952
Pre-IM	204,582	1	204,582	19,563	,000	,065	,993
Pre-SD	14,518	1	14,518	1,388	,240	,005	,217
Group	264,633	1	264,633	25,305	,000	,082	,999
School	3,517	1	3,517	,336	,562	,001	,089
Group * School	56,254	1	56,254	5,379	,021	,019	,637
Error	2949,080	282	10,458				
Total	305032,000	292					
Corrected Total	5383,658	291					

According to the results from the Table 4.31, it could be concluded the null hypothesis was rejected for the alpha level of 0.05 and so, in terms of self-efficacy construct of motivation, there was a statistically significant difference between students instructed with CBL method and the students instructed with traditionally designed instruction method (F (1,282) =25.305, p=0.000) in the favor of CBL instruction (experimental group) (see table 4.5). The partial eta square was 0.082 which could be accepted as large effect size (Cohen, 1988) and self-efficacy construct of motivation accounts for 8.2% variability while the power to detect the effect was 0.999. To see the covariates effect, again the estimated marginal means would be analyzed (see Table 4.32):

Table 4.32 Estimated marginal means for the post-SE in terms of groups

Group	Mean	Mean Difference (I-J)	S.E.
Control	31,061[a]	-1,916*	,269
Experimental	32,976[a]	1,916*	,268

In general, the post-SE mean score difference between control and experimental group students was 1.9174 (see table 4.5) whereas the estimated mean scores after the adjustment with covariates, this difference was found to be 1.9160 and the difference between mean scores was found statistically significant in the favor of students' instructed by CBL. So, it might be concluded that the students taught with CBL instruction (experimental group) had higher self-efficacy than the students taught with traditionally designed instruction (control group) in terms of learning acids and bases concepts.

4.3.2.8 Null Hypothesis 8

The twelfth null hypothesis was "there is no statistically significant difference between Anatolian and science high schools on the population means of the post-test scores of the students' self-efficacy construct of motivation to learn chemistry questionnaire (post-SE) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

According to the results from the Table 4.31, it could be concluded the null hypothesis was accepted for the alpha level of 0.05 and so, it might also be concluded that the school type did not differ in self-efficacy construct of motivation to learn chemistry for an alpha level 0.05 since, F (1,282) = 0,336, p = 0.562. In other words, the method applied in the experimental group did not make any significant difference on students' self-efficacy construct of motivation in terms of the school types they were attending. To see the covariates effect, again the estimated marginal means would be analyzed (see Table 4.33):

Table 4.33 Estimated marginal means for the post-SE in terms of schools

School	Mean	Mean Difference (I-J)	S.E.
Anatolian high school	32,143[a]	,250	,287
Science high school	31,894[a]	-,250	,287

According to the Table 4.33, the mean score difference between two schools was 0.25 whereas according to Table 4.7, these difference was 0.4795. The difference was caused by the covariates in the model. Even if there was a small difference between the school types, it was not found to be statistically significant.

4.3.2.9 Null Hypothesis 9

The ninth null hypothesis is "There is no statistically significant interaction between the treatment and school types on the population means of the post-test scores of the students' self-efficacy construct of motivation to learn chemistry questionnaire (post-SE) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

In order to check this hypothesis, Table 4.31 could be applied once again. From the table it was found that the null hypothesis was rejected since *F* (1,282) = 5.379, p = 0.021. Therefore, it could be concluded that, there was an interaction between methods of teaching and school types on students' self-efficacy construct of motivation to learn chemistry. The implemented method for the experimental group make a significant difference on students' self-efficacy construct of motivation in terms of the school types they were attending. To gain an overview for post-SE scores in terms of schools as categorized in teaching method of chemistry, Figure 4.18 has been given:

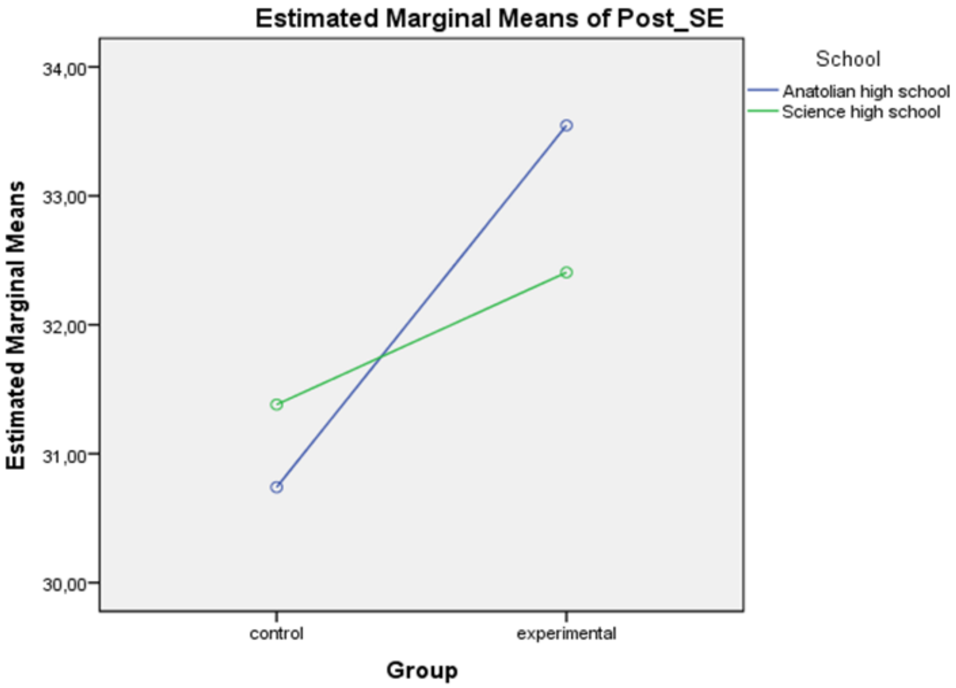

Figure 4.18 Graph of post-SE scores in terms of school types as categorized in group

4.3.2.10 Null Hypothesis 10

The tenth null hypothesis is "there is no statistically significant difference between students taught via CBL instruction and traditionally designed instruction on the population means of the post-test scores of the anxiety construct of motivation to learn chemistry questionnaire (post-ANX) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

A follow-up ANCOVA was conducted for checking this hypothesis. Table 4.34 gives the related results:

Table 4.34 Follow-up ANCOVA for post-ANX dependent variable

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Corrected Model	491,849[a]	9	54,650	8,941	,000	,222	1,000
Intercept	27,364	1	27,364	4,477	,035	,016	,559
Pre-ABT	11,101	1	11,101	1,816	,179	,006	,269
Pre-SE	24,518	1	24,518	4,011	,046	,014	,514
Pre-ANX	15,359	1	15,359	2,513	,114	,009	,352
Pre-GO	1,261	1	1,261	,206	,650	,001	,074
Pre-IM	61,578	1	61,578	10,075	,002	,034	,886
Pre-SD	49,929	1	49,929	8,169	,005	,028	,813
Group	10,166	1	10,166	1,663	,008	,006	,251
School	18,910	1	18,910	3,094	,080	,011	,418
Group * School	9,638	1	9,638	1,577	,210	,006	,240
Error	1723,644	282	6,112				
Total	112004,000	292					
Corrected Total	2215,493	291					

From the Table 4.34, it could be seen that the null hypothesis was rejected for an alpha level of 0.05, F (1,282) = 1.663, p = 0.008. So, there was a statistically significant difference between students' anxiety construct of motivation when they were instructed with CBL method or traditionally designed instruction method in the favor of CBL instruction (experimental group). To see the covariates effect, again the estimated marginal means would be analyzed (see Table 4.35):

Table 4.35 Estimated Marginal Means for the post-ANX in terms of groups

Group	Mean	Mean Difference (I-J)	S.E.
Control	19,198[a]	-,376	,206
Experimental	19,573[a]	,376	,205

According to the Table 4.5, the mean score differences for experimental and control groups were 0.4467 in the favor of experimental group whereas it was found as 0.376 after the covariates' effect in Table 4.35. Even if science high school students scored a bit higher than Anatolian high school students on anxiety construct of motivation, this difference was also found to be statistically significant.

4.3.2.11 Null Hypothesis 11

The eleventh null hypothesis is "There is no statistically significant difference between Anatolian and science high school on the population means of the post-test scores of the students' anxiety construct of motivation to learn chemistry questionnaire (post-ANX) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

According to the results from the Table 4.34, it could be concluded the null hypothesis was accepted for the alpha level of 0.05 and so, it could also be concluded that the school types does not differ in terms of anxiety construct of motivation to learn chemistry for an alpha level 0.05 since, F (1,282) = 3,094, p = 0.080. In other words, the method applied in the experimental group made no significant difference on the anxiety construct of students' motivation to learn chemistry in terms of the school types they are attending. To see the covariates effect, again the estimated marginal means would be analyzed (see Table 4.36):

Table 4. 36 Estimated marginal means for the post-ANX in terms of schools

School	Mean	Mean Difference (I-J)	S.E.
Anatolian high school	19,675[a]	,579	,219
Science high school	19,096[a]	-,579	,219

According to the Table 4.36, the mean score difference between two schools was 0.579 in the favor of Anatolian high school whereas according to Table 4.7, these difference was 0.137. The difference was caused by the covariates in the model but even if there was a difference between students' anxiety construct scores of motivation according to the school types, it was not found to be statistically significant.

4.3.2.12 Null Hypothesis 12

The twelfth null hypothesis is "There is no statistically significant interaction between treatment and school types on the population means of the post-test scores of the students' anxiety construct of motivation to learn chemistry questionnaire (post-ANX) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

In order to check this hypothesis, Table 4.34 could be applied once again. From the table it was found that the null hypothesis was accepted since F (1,282) = 1,577, p = 0.210. Therefore, it could be concluded that, there was no statistically significant interaction between methods of teaching and school types on students' anxiety construct of motivation to learn chemistry. The implemented method for the experimental group did not make a significant difference on students' anxiety construct of motivation in terms of the school types they were attending. To gain an overview for post-ANX scores in terms of schools as categorized in teaching method of chemistry, Figure 4.19 has been given:

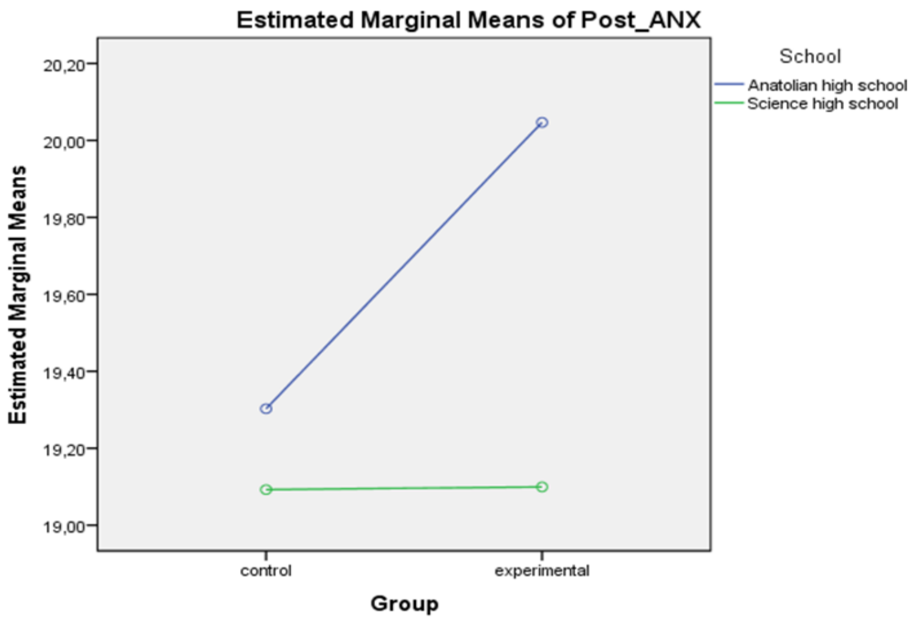

Figure 4.19 Graph of post-ANX scores in terms of school types as categorized in group

4.3.2.13 Null Hypothesis 13

The thirteenth null hypothesis is “there is no statistically significant difference between of students taught via CBL instruction and traditionally designed instruction on the population means of the post-test scores of the goal-orientation construct of motivation to learn chemistry questionnaire (post-GO) when the effects of students’ previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.”

In order to test the hypothesis another follow-up ANCOVA was conducted. Table 4.37 summarizes the results:

Table 4.37 Follow-up ANCOVA for post-GO dependent variable

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Corrected Model	3202,516[a]	9	355,835	23,632	,000	,430	1,000
Intercept	1,658	1	1,658	,110	,740	,000	,063
Pre-ABT	21,004	1	21,004	1,395	,239	,005	,218
Pre-SE	333,219	1	333,219	22,130	,000	,073	,997
Pre-ANX	159,220	1	159,220	10,574	,001	,036	,900
Pre-GO	623,258	1	623,258	41,392	,000	,128	1,000
Pre-IM	1,632	1	1,632	,108	,742	,000	,062
Pre-SD	5,255	1	5,255	,349	,555	,001	,091
Group	592,176	1	592,176	39,328	,000	,122	1,000
School	,418	1	,418	,028	,868	,000	,053
Group * School	86,939	1	86,939	5,774	,017	,020	,668
Error	4246,169	282	15,057				
Total	211130,000	292					
Corrected Total	7448,685	291					

From the Table 4.37, it could be seen that the null hypothesis was rejected for an alpha level of 0.05, F (1,282) = 39,328, p = 0.000. So, there was a statistically significant difference between students’ mean scores when they were instructed with CBL method instead of instructed with traditionally designed instruction method in the favor of CBL instruction (experimental group) on students’ goal-orientation construct of motivation. The partial eta square was 0.122 which could be accepted as medium effect size (Cohen, 1988) and goal-orientation construct of motivation accounts for 12 % variability. In addition to these, the observed power was 1.00 which is strong. To see the covariates effect, again the estimated marginal means would be analyzed (see Table 4.38):

Table 4.38 Estimated marginal means for the post-GO in terms of group

Group	Mean	Mean Difference (I-J)	Std. Error
Control	24,957[a]	-2,866*	,323
Experimental	27,823[a]	2,866*	,321

According to the Table 4.38, the mean score differences for experimental and control groups were 2.866 in the favor of experimental group whereas it was 2.8027 before the covariates' effect (see Table 4.5). Students in the experimental group scored higher than students in the control group on goal-orientation construct of motivation and this difference was found to be statistically significant. In other words, in terms of goal orientation the implemented method made a difference between experimental and control groups.

4.3.2.14 Null Hypothesis 14

The fourteenth null hypothesis is "there is no statistically significant difference between Anatolian and science high school on the population means of the post-test scores of the students' goal-orientation construct of motivation to learn chemistry questionnaire (post-GO) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

According to the results from the Table 4.37, it could be concluded that the null hypothesis was accepted for the alpha level of 0.05 ($F (1,282) = 0,336$, $p = 0.562$) which means the school type did not differ in goal-orientation construct of motivation to learn chemistry. In other words, the method applied in the experimental group did not make a significant difference on students' goal-orientation construct of motivation to learn chemistry in terms of the school types they are attending. To see the covariates effect, again the estimated marginal means would be analyzed (see Table 4.39):

Table 4.39 Estimated Marginal Means for the post-GO in terms of school

School	Mean	Mean Difference (I-J)	S.E.
Anatolian high school	26,433[a]	,086	,344
Science high school	26,347[a]	-,086	,344

According to Table 4.39, the mean score differences for Anatolian high school and science high schools were 0.086 in the favor of Anatolian High School whereas it was 0.7671 before the covariates' effect and in the favor of experimental effect (see Table 4.7). Students in the Anatolian high school scored higher than students in science high school on goal-orientation construct of motivation but this difference was not found to be statistically significant. In other words, in terms of goal orientation the implemented method made no difference between Anatolian and science high schools.

4.3.2.15 Null Hypothesis 15

The fifteenth null hypothesis is "There is no statistically significant interaction between treatment and school types on the population means of the post-test scores of the students' goal-orientation construct of motivation to learn chemistry questionnaire (post-GO) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

In order to check this hypothesis, Table 4.37 could be applied once again. From the table it was found that the null hypothesis was rejected since F (1,282) = 5.774 p = 0.017. Therefore, it could be concluded that, there was an interaction between methods of teaching and school types on students' goal-orientation construct of motivation to learn chemistry. The implemented method for the experimental group did not make a significant difference on students' goal-orientation construct of motivation in terms of the school types they were attending. To gain an overview for post-GO scores in terms of schools as categorized in teaching method of chemistry, Figure 4.20 has been given:

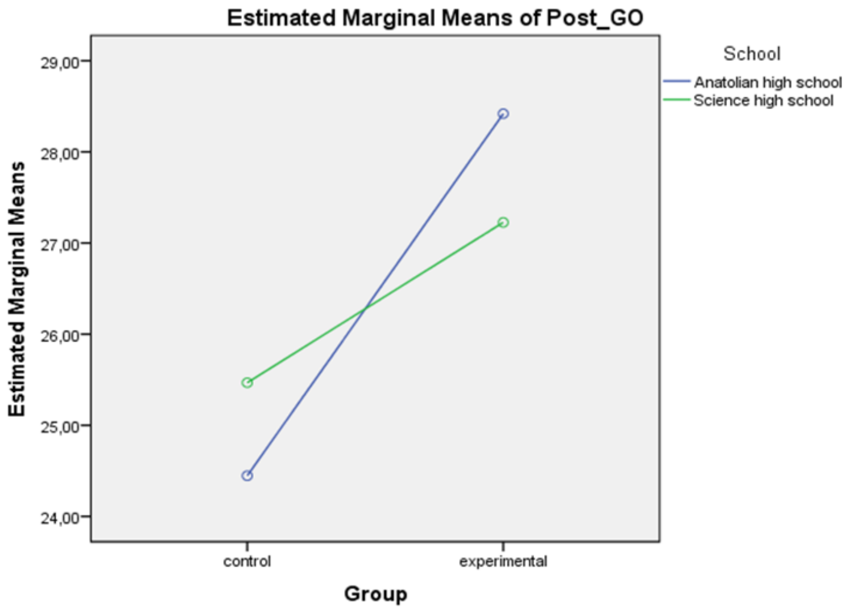

Figure 4.20 Graph of post-GO scores in terms of school types as categorized in group

4.3.2.16 Null Hypothesis 16

The sixteenth null hypothesis is “there is no statistically significant difference between of students taught via CBL instruction and traditionally designed instruction on the population means of the post-test scores of the intrinsic motivation construct of motivation to learn chemistry questionnaire (post-IM) when the effects of students’ previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.”

In order to test the hypothesis another follow-up ANCOVA was conducted. Table 4.39 summarizes the results:

Table 4.40 Follow-up ANCOVA for post-IM dependent variable

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Corrected Model	875,755[a]	9	97,306	18,129	,000	,367	1,000
Intercept	13,043	1	13,043	2,430	,120	,009	,342
Pre-ABT	9,014	1	9,014	1,679	,196	,006	,252
Pre-SE	21,370	1	21,370	3,981	,047	,014	,511
Pre-ANX	48,043	1	48,043	8,951	,003	,031	,847
Pre-GO	74,351	1	74,351	13,852	,000	,047	,960
Pre-IM	48,451	1	48,451	9,027	,003	,031	,849
Pre-SD	30,083	1	30,083	5,605	,019	,019	,655
Group	125,277	1	125,277	23,340	,000	,076	,998
School	1,175	1	1,175	,219	,640	,001	,075
Group * School	8,211	1	8,211	1,530	,217	,005	,234
Error	1513,653	282	5,368				
Total	115893,000	292					
Corrected Total	2389,408	291					

From the Table 4.40, it could be seen that the null hypothesis was rejected for an alpha level of 0.05, F (1,282) = 23,340, p = 0.000. So, there was a statistically significant difference between students' intrinsic motivation construct of motivation when they were instructed with CBL method instead of traditionally designed instruction method in the favor of CBL instruction (experimental group) (see Table 4.5). The partial eta square was 0.076 which could be accepted as medium effect size (Cohen, 1988) and intrinsic motivation construct of motivation accounts for 0.7.6% variability with a power of 0.998. To see the covariates effect, again the estimated marginal means would be analyzed (see Table 4.41):

Table 4.41 Estimated marginal means for the post-IM in terms of groups

Group	Mean	Mean Difference (I-J)	S.E.
Control	19,049[a]	-1,318*	,193
Experimental	20,367[a]	1,318*	,192

According to the Table 4.5, the mean score differences for experimental and control groups were 1.3396 in the favor of experimental group whereas in Table 4.41, it was found as 1,318 after the covariates' effect. To conclude, experimental group students scored higher than control group students on intrinsic motivation construct of motivation and this difference was found to be statistically significant.

4.3.2.17 Null Hypothesis 17

The seventeenth null hypothesis is "there is no statistically significant difference between Anatolian and science high school on the population means of the post-test scores of the students' intrinsic motivation construct of motivation to learn chemistry questionnaire (post-IM) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

According to the results from the Table 4.40, it could be concluded the null hypothesis was accepted for the alpha level of 0.05 that means the school type did not differ on intrinsic motivation construct of motivation to learn chemistry for an alpha level 0.05 since, $F(1,282) = 0.219$ $p = 0.640$. In other words, the method applied in the experimental group did not make a significant difference on intrinsic motivation construct of motivation to learn chemistry in terms of the school types they were attending. To see the covariates effect, again the estimated marginal means would be analyzed (see Table 4.42):

Table 4.42 Estimated marginal means for the post-IM in terms of schools

School	Mean	Mean Difference (I-J)	S.E.
Anatolian high school	19,636[a]	-,144	,205
Science high school	19,780[a]	,144	,205

According to the Table 4.42, the mean score differences for Anatolian high school and science high school were 0.6369 in the favor of science high school whereas in Table 4.7, it is found as 0,144 after the covariates' effect. This was a remarkable difference which could be accepted as evidence that applying appropriate covariates gives healthy results. To conclude, science high school students scored higher than Anatolian High School students on intrinsic motivation construct of motivation and this difference was not found to be statistically significant.

4.3.2.18 Null Hypothesis 18

The eighteenth null hypothesis is "there is no statistically significant interaction between treatment and school types on the population means of the post-test scores of the students' intrinsic motivation construct of motivation to learn chemistry questionnaire (post-IM) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

In order to check this hypothesis, Table 4.39 could be applied once again. From the table it was found that the null hypothesis was accepted since F (1,282) = 1,530, p = 0.217. Therefore, it could be concluded that, there was not any interactions between methods of teaching and school types on students' intrinsic motivation construct of motivation to learn chemistry. The implemented method for the experimental group did not make a significant difference on students' intrinsic motivation construct of motivation in terms of the school types they were attending. To gain an overview for post-IM scores in terms of schools as categorized in teaching method of chemistry, Figure 4.21 has been given:

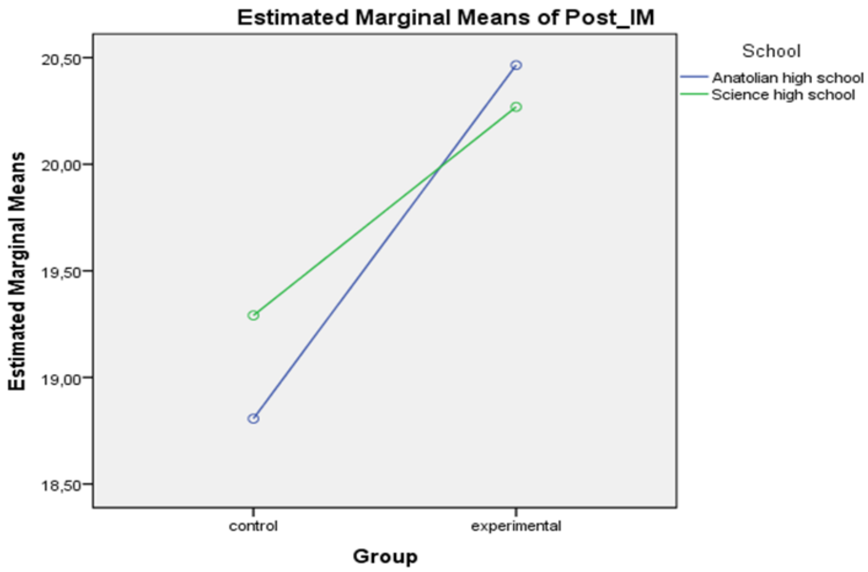

Figure 4.21 Graph of post-IM scores in terms of school types as categorized in group

4.3.2.19 Null Hypothesis 19

The nineteenth null hypothesis is “there is no statistically significant difference between of students taught via CBL instruction and traditionally designed instruction on the population means of the post-test scores of the self-determination construct of motivation to learn chemistry questionnaire (post-SD) when the effects of students’ previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled.”

In order to test the hypothesis another follow-up ANCOVA was conducted. Table 4.43 summarizes the results:

Table 4.43 Follow-up ANCOVA for post-SD dependent variable

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Corrected Model	504,230[a]	9	56,026	10,837	,000	,257	1,000
Intercept	71,722	1	71,722	13,873	,000	,047	,960
Pre-ABT	5,608	1	5,608	1,085	,299	,004	,180
Pre-SE	15,570	1	15,570	3,012	,084	,011	,409
Pre-ANX	28,382	1	28,382	5,490	,020	,019	,646
Pre-GO	14,298	1	14,298	2,766	,097	,010	,381
Pre-IM	47,544	1	47,544	9,196	,003	,032	,856
Pre-SD	22,562	1	22,562	4,364	,038	,015	,549
Group	74,231	1	74,231	14,359	,000	,048	,965
School	5,326	1	5,326	1,030	,311	,004	,173
Group * School	18,403	1	18,403	3,560	,060	,012	,468
Error	1457,889	282	5,170				
Total	123489,000	292					
Corrected Total	1962,120	291					

From the Table 4.43, it could be seen that the null hypothesis was rejected for an alpha level of 0.05, F (1,282) = 14,359, p = 0.000. So, there was a statistically significant difference between students' self-determination construct of motivation when they were instructed with CBL method instead of traditionally designed instruction method in the favor of CBL instruction (experimental group). The partial eta square was 0.048 which could be accepted as medium effect size (Cohen, 1988) and self-determination construct of motivation accounts for 4.8 % variability on students' self-determination construct of motivation with a power of 0.965. To see the covariates effect again the estimated marginal means might be analyzed (see table 4.44):

Table 4.44 Estimated marginal means for the post-SD in terms of groups

Group	Mean	Mean Difference (I-J)	S.E.
Control	19,885[a]	-1,015*	,189
Experimental	20,899[a]	1,015*	,188

According to Table 4.5, the mean score differences for experimental and control groups were 1.0425 in the favor of experimental group whereas in Table 4.44, it was found as 1.015 after the covariates' effect. To conclude, experimental group students scored higher than control group students on self-determination construct of motivation and this difference was found to be statistically significant.

4.3.2.20 Null Hypothesis 20

The twentieth null hypothesis is "there is no statistically significant difference between Anatolian and science high school on the population means of the post-test scores of the students' self-determination construct of motivation to learn chemistry questionnaire (post-SD) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

According to the results from the Table 4.43, it could be concluded the null hypothesis was accepted for the alpha level of 0.05 that school types did not differ in understanding on students' scores on self-determination construct of motivation to learn chemistry for an alpha level 0.05 since, $F(1,282) = 1.030$, $p = 0.311$. In other words, the method applied in the experimental group did not make a significant difference on students' scores for the self-determination construct of motivation to learn chemistry in terms of the school types they were attending. To see the covariates effect, again the estimated marginal means would be analyzed (see Table 4.45):

Table 4.45 Estimated marginal means for the post-SD in terms of schools

School	Mean	Mean Difference (I-J)	S.E.
Anatolian high school	20,546[a]	,307	,202
Science high school	20,238[a]	-,307	,202

According to the Table 4.45, the mean score differences for experimental and control groups were 0.307 after the covariates' effect which was in the favor of Anatolian high school whereas it was found as 0.0754 in the favor of science high school (see table 4.7). Thus, it was revealed that Anatolian high school students scored higher than science high school students on self-determination construct of motivation but this difference was not found to be statistically significant.

4.3.2.21 Null Hypothesis 21

The twenty-first null hypothesis is "there is no statistically significant interaction between treatment and school types on the population means of the post-test scores of the students' self-determination construct of motivation to learn chemistry questionnaire (post-SD) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry are controlled."

In order to check this hypothesis, Table 4.43 could be applied once again. From the table it was found that the null hypothesis was accepted since F (1,282) = 3.560, p = 0.06. Therefore, it could be concluded that, there was not no interactions between methods of teaching and school types on students' self-determination construct of motivation to learn chemistry. In other words, the implemented method for the 7frgd experimental group did not make a significant difference on students' self-determination construct of motivation in terms of the school types they were attending. To gain an overview for post-SD scores in terms of schools as categorized in teaching method of chemistry, Figure 4.22 has been given:

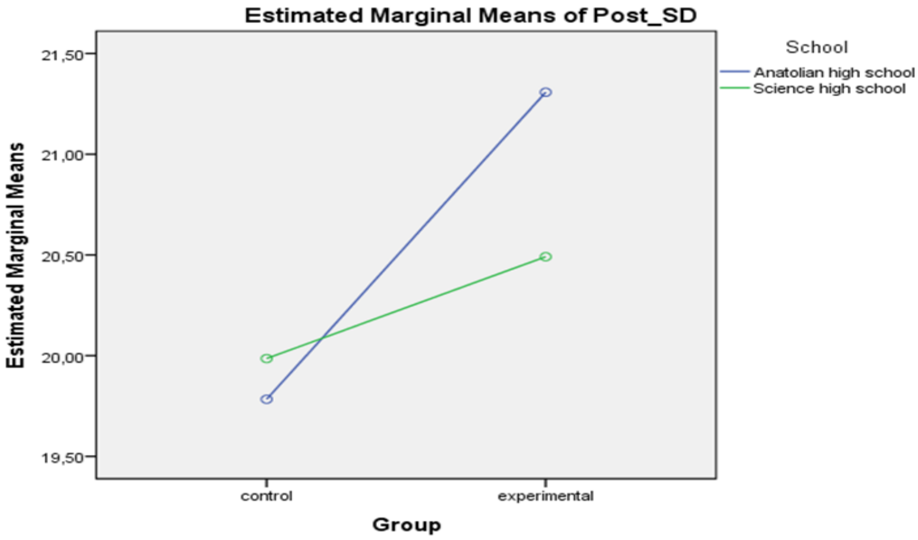

Figure 4.22 Graph of post-SD scores in terms of school types as categorized in group

When the MANCOVA's and follow-up ANCOVA's compare mean analysis was analyzed, in terms of group and school independent variables, all results were matching. So, it could be concluded that the results were double checked.

4.4 Interpreting the Results of Cases Implemented in Experimental Groups According to Researcher's Notes during Lecture Hours

The results that cover how the teachers act; the students' answers to the cases that were studied in the class hours conducted in the experimental group, students' difficulties and their behaviors were analyzed in a detailed format for each case. In this part, the main implementation processes for each case, the crucial parts and the specific situations occurred during the study were given:

4.4.1 Karate Kids

This case was designed for making the students remember what they learned in the eighth grade about acids and bases. It was created upon an analogy so that it could be easier for students to remember their prior knowledge. In this case there were five questions. According to the researchers' notes, the students in each school should relate the case with their previous knowledge about basic acids and bases concepts like:

- Acids have a sour taste,
- They give neutralization reactions with bases,
- Bases are bitter and slippery,
- Acids turn litmus paper red and bases to purple.

Even if they could remember the basic properties of acids and bases which could also be found in the case, when they were asked if there were any other properties of acids and bases, they could not answer that question properly. Many students could not remember the reactions of acids and bases with metals.

The students also easily gave examples to acids and bases and their strength but when the reason of thinking an acid or base to be strong, there were some students (around 15%) that answered like “because it was taught like that” or “I do not know”.

The students in the class also had difficulty in deciding about the reason why one of the famous karate teachers changed his philosophy since they could not make the connection between this question and the theories of acids and bases. Since the students could not answer this question properly, the teacher found a chance to emphasize on the nature of science (NOS) aspect. The teacher asked the students to think about an idea in science that as not supported anymore. Then the students gave different answers in different classes. To give an example, one student in the science high school said “this was because gaining a new knowledge that was not fit to the karate teacher’s previous knowledge”. Another student said “even if the material is acidic it also includes base or vice versa. It was because of this”. Another student answered this question as “acids and bases may show the same properties so that the teacher changes his previous belief”. According to these answers, the teachers directed the students to the correct knowledge: an idea, a belief, a theory, a law or a philosophy could change in time when some other evidences found as it happened in this case. In this question, the students seemed to be very focused on finding the correct answer. Their prior knowledge was not enough to find the answer; however, they had fun during their investigation for the correct answer and during discussion.

In addition to these, the teachers generally tried to identify the misconceptions the students might have. The related misconceptions were tried to be directed to the students according to the students' answers. For this reason, during the class hours different misconceptions were analyzed with the class. However, there was one more lecture hour in Anatolian High school and two more lecture hour in science high school in each week to mention all misconceptions during the study. So, according to the researchers' notes; the related misconceptions were mentioned to students and they discussed with them as much as possible for this case in the lectures the researcher found a chance to observe.

4.4.2 Acids and Bases in Our Daily Life

In this case, the acids and bases in our daily life were analyzed from a different point of view which also takes living a healthy life into account. For this reason, some acids and bases found inside our foods naturally were given to the students in a table and some artificial foods that include the same acids and bases but formed chemically were given in another table. In the second table there were also the illnesses these chemically formed acids and bases should cause were also listed. There were five questions according to this case that include misconceptions about acids and bases.

According to the researchers' notes, the students answered all the questions correctly except the fifth question which also had interdisciplinary purposes (making a connection with biology course) for being asked even if the students seemed to be motivated and active for finding its answer. In this question, the students were given another table that include some fruits and vegetables, their categorization according to the acids and bases in their structures and the categorization according to what they do to human blood; acidic or basic when they were eaten. Then the students were asked if they could explain how an acidic fruit or vegetable made the blood basic or how a basic fruit or vegetable made the blood acidic. It was not very shocking for the teachers and researcher when they come face to face with the students who could not answer this question since they have not seen the buffer solutions yet. But this question was asked to the students for taking their attention, increasing their curiosity, directing the students for searching about the answer and for using this question to make a link with the buffer solutions when they would learn in the next class hours. So, the teachers only took students' responses in the related week by guiding the students to search for it after the lecture hours and mentioning that they would turn to this question in the next weeks.

The teachers also mentioned as many misconceptions during the lecture as possible since this case also included many misconceptions according to acids and bases. According to the students' answers, the teachers were directing the students to the correct conceptions. Since the case was very explanatory, the students generally had no difficulty in finding the correct explanations in both schools.

According to the researcher notes, it was a good and motivational process for the students in each school since their curiosity made them be more willing to learn the concepts and they asked the answer of this question until they learned it in another case. Then many of them made the connection by themselves easily.

4.4.3 Magical Mask

In this case, the students were given a fantastic game and its rules. Then they were asked to answer the related questions. This case also took analogy into its formation process since students mainly had learning difficulties and many misconceptions according to Bronsted-Lowry acids and bases theory and by the help of analogy, it was easier for students to understand and overcome misconceptions. Moreover, since this theory forms a base for learning more complicated concepts about acids and bases, it needed to be taught very carefully.

There were three questions in the case and according to the notes, at first students could not understand what they were asked in the questions but with correct guidance, they answered the first two questions in the case easily and correctly. In the third question, it was asked the students to compare the case with one of the atom theories. When the answers to this question were checked according to the researchers' notes, nearly half of Anatolian high school students in the experimental groups answered this question wrong. So the teacher needed to lead the students to the correct answer by spending more time on discussion part. Students were mainly thinking about hydrogen atoms so that they were thinking about Arrhenius atom theory to be more similar to the case. When the other group members defend their ideas, at the end all class found the correct answer to this question.

What was important here is that, since there were only three questions for students to answer in this case, so the researcher was planning to give another case (Ayşegül's puzzle with onion) in this week. Since the discussion part took more time than expected it could not be distributed to the students.

At the end of this lecture, one other nature of science aspect was also introduced to the students; the facts about law and theory next to the changeable structure of science. The students had a shock when they learned that law and theory were not what they knew since they believed law could not be changed whereas theory could. Whereas the correct version was that laws could also change as theory but the difference was because law had a mechanism to be explained instead of theory. Then the aspect of science being changing also emphasized once again since the theories about acids and bases were given in this case. During teaching nature of science aspects, the researcher observed that the students become more motivated and showed to have fun when they learn new things that they did not know before.

4.4.4 Purification of Water

This case was designed for teaching the students' about pH, pOH, their relations with each other, hydrogen and hydroxide atoms. One other aim of this case was for protecting the misconceptions to be formed or overcoming them related to these concepts. Moreover, since the students had learning difficulties according to the teachers that took a part in this study, water hardness and its causes were also aimed to be taught to the students.

There were twelve questions about this case. According to the researchers' notes, students were very successful in the first eleven questions since they found the correct answers easily from the case. In the twelfth question, it was searched by the researcher if the students could detect that the given matters showed amphoteric properties. But this question was the only question that the discussion environment became active between students in both schools since there were different answers to this question. To give an example, many students tried to answer this question directly linking it to only one case according to Bronsted-Lowry acids and bases and could not detect the amphoteric structure in the given materials. Then the teachers guided the discussion and the correct answer was reached by the students.

As mentioned in each case, again the misconceptions were emphasized during the lecture according to students' answers by each teacher and the free lecture hours were left directly to the misconceptions about the related case.

4.4.5 Pınar's Table Lamp

In this case, the students were tried to be taught about the strong/weak acids, equilibrium constant, ionization percentage concepts considering the related misconceptions in the literature. There were eleven questions in this case and some questions needed mathematic skills to be used since there were mathematical justifications to be used to defend students' answers. The reason of adding mathematical justifications was for the possibility of having some students have misconceptions or for protecting the students to have those misconceptions.

This case was designed according to interdisciplinary teaching with physics and in addition to that, in this case the students asked to make connections between their previous knowledge about periodic table, electronegativity and chemical bonds units of chemistry.

According to the researchers' notes, students were good at answering each question since their mathematic skills were also very good. There was also no problem in justifying the related questions. In addition to that, they could easily link their previous knowledge to new knowledge in the class.

Even if this was the case, before making the mathematical justifications with their groups, it was observed that there were some students mainly in the science high school that gave wrong answers to these questions. This was mainly because of their misconceptions. But they had changed their minds accordingly after they discussed them with their groups and with whole class. Moreover, the misconceptions related to this case were also examined in the lecture hour left for misconceptions in each week in order to check whether the students still held the related misconceptions or not.

4.4.6 Stomach's Enemy: Ulcer

This case was designed for mainly teaching about neutralization reactions, titrations and the concepts related to them. Next to these, the possible misconceptions were studied in some questions so that the students were planned to be protected from having them. Also, students' higher order skills were tried to be improved. In addition to them, an interdisciplinary teaching with biology was applied next to getting help from students' mathematical skills.

First of all, this was the longest case studied in the classes since there were twenty-one questions according to this case. Second, students gain awareness about an important health problem called ulcer that is very common around the youth nowadays.

According to the researchers' notes, students were very active and motivated especially in Anatolian high school experimental groups when the discussion was about the illness and how to be protected from it. They were sharing their opinions and memories with each other. Even if this was the case, there was also an unexpected result occurred; nearly quarter of the students in both schools had difficulty in drawing the graphs about the titrations. For this reason, each group needed to discuss the graphs by drawing them on the boards which took a long time unexpectedly.

The misconceptions were also mentioned according to students' answers and it was observed that many of the students in science high school thought indicator was a must for titration at the beginning. Thus, in the next lecture hour left for misconceptions, the teacher needed to emphasize more on this misconception and the reason why it was not true.

4.4.7 Making Our Own Fuel with Biodiesel

This case was designed for making the students prepared for the future basically. They should learn the logic behind the biodiesel fuels and their relation to chemistry so that they could not think learning chemistry was nonsense. In addition to this, another aim of this case was to teach students about weak acid and strong base titrations.

According to the researchers' notes, it was the case the students had more fun when compared to others since nearly all of the students in both schools were motivated to read, answer and learn about. They were asking many questions and all ready to learn new information about this case. There were six questions at the end of the case and students had no difficulty in answering them except the fourth one that asked the students about the strength of the acid. There were different ideas about this question and at the end the teacher had to act a facilitator more than the other weeks and let the students find a related article from the internet for the next hour since they couldn't agree on the correct answer in the expected lecture hour.

4.4.8 Selçuk's Water Boiler

This case tried to teach the weak acid weak base relations and their equilibrium constants. In the case there were nine questions. According to the researchers' notes, the students in science high school generally made mistakes on the first two questions in which they needed to write the equation between the lime and vinegar and lime and lime dissolver. They forget to include carbon dioxide gas to be free according to the reaction and the other questions were answered easily.

4.4.9 Acid-Base Equilibrium in Our Body

An interdisciplinary teaching with biology was designed for teaching the buffer solutions and their usage areas in our daily lives. There were seven questions related to the case.

According to the researchers' notes, even if the students in both schools understood the buffer solutions, at first, they had difficulty in finding examples to the buffer solutions from daily life. So, the teacher gave it as homework to the students.

At the end of this case, the students were reminded about the last question from the second case: the acids and bases from our daily life which was asking about the reason of a vegetable that has acid in its structure made the blood basic when eaten. The students easily answered this question when they heard it which made them very happy to learn the answer to that question.

4.4.10 Plants and Salts

The last case applied to the students was about the salts and the anions and cations in salt structures. This was an important concept since many students had misconceptions about these concepts according to the literature or they had difficulty in understanding them. There were eleven questions in the case and since they were designed to teach step by step; the students did not have any trouble in answering any of the questions even if they were frightened as they read the name of the case at the beginning of the lecture but their fear of not learning the concepts was over as they saw themselves answering the questions easily.

During teaching this case, the teachers mainly had difficulty in teaching students the reasons of the anions' and cations' being acidic/basic or neutral in both schools. Many questions were asked to the teacher even if at the end there were some students that could not understood the logic to this in both schools.

After this case had finished, there were also many students that felt relief in both schools and could not believe why they found the salts very difficult to understand before. According to the researchers' notes, these students became motivated to learn chemistry a bit more.

4.4.11 Ayşegül's Puzzle with Onion (if time is left)

Since this case was designed to apply just after the magical mask case and there were no time left, it could not be applied on students.

4.5 Results of the Acids and Base Test (ABT)

In the ABT, there were 33 questions with five options (from A to E) and under each question, there was another option as "I Don't Know" so that the possibility of students' giving an answer to the questions they really do not know would be prevented. In addition to that, the students would not leave a question unanswered which was causing missing values. This test was applied on students as a pre-test before the implementation and as a post-test after the implementation. The test was developed for determining the students' understanding of the acids and bases concepts. Some of the alternatives of the questions which were verbal include misconceptions related to acids and bases as the distractors and the rest of the questions could be solved by using mathematical skills next to acid-base chemistry knowledge. Table 4.46 shows the percentages of the students who gave correct answers on pre-ABT and post-ABT questions in terms of group independent variable.

Table 4.46 Summary of pre and post ABT results in terms of groups

	Pre-Test						Post-Test					
	Control Group			Experimental Group			Control Group			Experimental Group		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%
Item 1	145	130	90.3	147	134	91.2	145	143	98.6	147	146	99.3
Item 2	145	105	72.4	147	108	73.5	145	126	86.9	147	147	100
Item 3	145	104	71.7	147	108	73.5	145	128	88.3	147	147	100
Item 4	145	124	85.5	147	116	78.9	145	140	96.6	147	144	98

Table 4.46 Summary of pre and post ABT results in terms of groups (continued)

	Pre-Test						Post-Test					
	Control Group			Experimental Group			Control Group			Experimental Group		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%
Item 5	145	141	97.2	147	144	98	145	145	100	147	147	100
Item 6	145	108	74.5	147	110	74.8	145	114	78.6	147	138	93.9
Item 7	145	139	95.9	147	142	96.6	145	140	96.6	147	147	100
Item 8	145	140	96.6	147	142	96.6	145	143	98.6	147	145	98.6

Table 4.46 Summary of pre and post ABT results in terms of groups (continued)

	Pre-Test						Post-Test					
	Control Group			Experimental Group			Control Group			Experimental Group		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%
Item 9	145	100	69	147	104	70.7	145	122	84.3	147	147	100
Item 10	145	78	53.8	147	81	55.1	145	113	77.9	147	138	93.9
Item 11	145	97	66.9	147	97	66	145	134	92.4	147	147	100
Item 12	145	117	80.7	147	114	77.6	145	130	89.7	147	144	98

Table 4.46 Summary of pre and post ABT results in terms of groups (continued)

	Pre-Test						Post-Test					
	Control Group			Experimental Group			Control Group			Experimental Group		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%
Item 13	145	84	57.9	147	80	54.4	145	110	75.9	147	129	87.8
Item 14	145	15	10.3	147	16	11	145	32	22.1	147	111	75.5
Item 15	145	103	71	147	102	70.3	145	124	85.5	147	145	98.6
Item 16	145	36	24.8	147	40	27.5	145	45	31	147	107	72.8

Table 4.46 Summary of pre and post ABT results in terms of groups (continued)

	Pre-Test						Post-Test					
	Control Group			Experimental Group			Control Group			Experimental Group		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered	%	Total # of Students	Total # of questions answered correctly	%
Item 17	145	116	80	147	113	76.9	145	127	87.6	147	137	93.2
Item 18	145	66	45.6	147	65	44.2	145	98	67.6	147	123	83.7
Item 19	145	72	49.7	147	74	50.3	145	105	72.4	147	129	87.8
Item 20	145	131	90.3	147	129	87.8	145	137	94.5	147	147	100

Table 4.46 Summary of pre and post ABT results in terms of groups (continued)

	Pre-Test						Post-Test					
	Control Group			Experimental Group			Control Group			Experimental Group		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%
Item 21	145	112	77.2	147	115	78.2	145	126	86.9	147	146	99.3
Item 22	145	54	37.2	147	56	38.1	145	95	65.5	147	127	86.4
Item 23	145	97	66.9	147	99	67.3	145	117	80.7	147	134	91.2
Item 24	145	78	53.8	147	84	57.1	145	100	69	147	128	87.1

Table 4.46 Summary of pre and post ABT results in terms of groups (continued)

	Pre-Test						Post-Test					
	Control Group			Experimental Group			Control Group			Experimental Group		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered	%	Total # of Students	Total # of questions answered correctly	%
Item 25	145	48	33.1	147	47	32	145	103	71	147	132	89.9
Item 26	145	87	60	147	90	61.2	145	110	75.6	147	125	85
Item 27	145	101	69.7	147	99	67.3	145	104	71.7	147	130	88.4
Item 28	145	44	30.3	147	47	32	145	125	86.2	147	134	91.2

Table 4.46 Summary of pre and post ABT results in terms of groups (continued)

	Pre-Test						Post-Test					
	Control Group			Experimental Group			Control Group			Experimental Group		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	of questions answered	%	Total # of Students	Total # of questions answered correctly	%
Item 29	145	60	41.4	147	70	47.6	145	92	63.4	147	127	86.4
Item 30	145	32	22.1	147	26	17.7	145	58	40	147	121	82.3
Item 31	145	105	72.4	147	101	68.7	145	131	90.3	147	147	100
Item 32	145	81	55.9	147	80	54.4	145	136	93.8	147	140	95.2
Item 33	145	108	74.5	147	112	76.2	145	139	95.9	147	142	96.6

According to the Table 4.46, in terms of pre-ABT scores there were three easy questions for both experimental and control group whose mean scores were very close: items 5, 7 and 8. For item 5, the percentage of the correct answers for the control group was 97.2% whereas; it was 98% for the experimental group. For the item 7, the percentage of correct answers was 95.9 and it was 96.6 for the experimental group. For the item 8, the percentage of correct answers for the control group was 96.6 and it was 96.6 for the experimental group too. When the most difficult questions were analyzed, it was the item 14 for both control and experimental groups with the percentages of 10.3 and 11 for the control and experimental groups respectively.

In terms of post-ABT scores, the easiest question was Item 5 for the control group that was 100% correctly answered and for the experimental group, there were eight questions that were answered with 100% correctly. They were items 2, 3, 5, 7, 9, 11, 20 and 31. The most difficult question was Item 14 for the control group students, with the percentage of correct answers 22.1 and Item 16 for the experimental group students, with the percentage of 72.8 correct answers.

Even if most of the pre-ABT mean scores are close to each other for the experimental and control groups, the most significant difference among the scores on the pre-ABT for the experimental and the control groups was on item 4 with the difference of 6.6% in the mean scores which means 6.6% students in the experimental group scored higher than the control group students before the implementation. For the post-ABT, this difference was on the item 14 with the difference of 53.4 % in the mean scores of experimental and control groups. In other words, 53.4% students in the experimental group scored higher than the control group students.

The smallest difference among the scores on the pre-ABT for the experimental and the control groups was on the item 8 with the value of 0; in other words, this question was answered correctly nearly with the same percentage for both groups. For the post-ABT, the smallest difference among the scores for the experimental and control groups was on the item 5 with the value of 0 which means the students in both groups answered this question correctly nearly with the same rate.

An interesting result could be seen in the Table 4.46 was, for items 5, 7 and 8 in pre-ABT, it was seen that the students in the control group answered correctly with the highest rates. This result was also true for the experimental group. When the results of post-ABT were analyzed, items 5, 7 and 8 were also answered correctly by most of the control and experimental groups too. So, these questions may be the ones the students already know from the 8th grade so that they were all answering the questions correctly in pre and post-test. A closer result was also seen in the item 20 since it was also answered correctly by most of the students in both groups for both pre and post-tests.

Moreover, as mentioned before the items 13, 16, 19 and 28 included misconceptions that were designed for this study. When the students' results were analyzed according to Table 4.46 for these questions, it could be concluded from the pre-ABT results that the students in both groups have the misconceptions which were formed for this study by the researcher before the implementation (they scored below 85%). When the post-ABT results were analyzed, it could be concluded that, the misconceptions of the control group students were mainly remedied for the item 28 ("Stippling O_2 that was formed after metabolical events is one of the missions of the buffer solutions") since the students answered this question correctly in the post-ABT with the percentage above 85% (it was 86.2%). It was also revealed the control group students to still have the misconceptions for the item 13, item 16 and item 19 since their percentages of answering these questions correctly were lower than 85 (75.9%, 31%, 72.4% respectively). When the experimental group students' results were analyzed, again for the pre-ABT, all students seemed to have the misconceptions since their correct responses were below 85%. For the post-ABT, the experimental group students could be accepted as remedied the misconceptions for the items 13,19 and 28 except the item 16 since its correct answer percentage was below 85 (it was 72.8%).

The change on percentage scores between pre-test and post-test for each item was presented in the Table 4.47 in terms of group independent variable:

Table 4.47 The change on percentage scores between pre & post-tests in terms of groups

	Gain Score Percentage (Post-Test Score Percentage – Pre-Test Score Percentage)	
Item #	Control Group (%)	Experimental Group (%)
Item 1	8,3	8,1
Item 2	14,5	26
Item 3	16,6	26,5
Item 4	11,1	19,1
Item 5	2,8	2
Item 6	4,1	19,1
Item 7	0,7	3,4
Item 8	2	2
Item 9	15,3	29,3
Item 10	24,1	38,8
Item 11	25,5	34
Item 12	9	20,4
Item 13	18	33,4
Item 14	11.8	64,5
Item 15	14,5	28,3
Item 16	6	45,3
Item 17	7,6	16,3
Item 18	22	39,5
Item 19	22,7	37,5
Item 20	4,2	12,2
Item 21	9,7	21,1
Item 22	28,3	48,3
Item 23	13,8	23,9
Item 24	15,2	30
Item 25	37,9	57,9
Item 26	15,6	23,8

Table 4.47 The change on percentage scores between pre & post-tests in terms of groups (continued)

	Gain Score Percentage (Post-Test Score Percentage – Pre-Test Score Percentage)	
Item #	Control Group (%)	Experimental Group (%)
Item 27	2	21,1
Item 28	55,9	59,2
Item 29	22	38,8
Item 30	42	64,6
Item 31	17,9	31,3
Item 32	37,9	40,8
Item 33	1,4	20,4

The scores in Table 4.47 were calculated by subtracting the percentage of pre-ABT scores from the percentage of post-ABT scores directly. The most significant change on scores was on the item 28 for the control group (55.9%). This question was about the daily life usage and the missions of buffer solutions. In other words, the students in the control group understood the buffer solutions missions and their daily life usage areas better after the study. For experimental group, the most significant change in scores were seen in item 14 (64.5%) and item 30 (64.6%). Item 14 was about the anion and cation properties in terms of acids and bases and item 30 was about neutralization reactions between weak base and strong acid. Both questions were designed to detect the students' misconceptions and according to these results, it could be concluded that the students in the experimental group showed a high progress after the implementation that the misconceptions about these questions were remedied.

In addition to these, the smallest score change percentage was on item 7 for the control group (0.7%). This item was about acids and bases from our daily life and their properties that include misconceptions. When this difference was compared with the Table 4.46, it was found that control group students did not have the misconceptions related to item 7 before the implementation since they scored above 85% both before and after the implementation. So, it could be said that, for the control group students the implementation did not make much difference on students' learning of acids and bases. For the experimental group, the smallest score change percentage was on item 5 (2%) and item 8 (2%). Item 5 was about conjugate acids and bases and item 8 was about finding pH and pOH values from the concentrations of hydrogen ion. When this difference was compared with the Table 4.46, it was found that experimental group students did not have those misconceptions related to item 5 and item 8 before the implementation since they scored above 85% both before and after the implementation. So, it could be revealed that, for the experimental group the implementation did not make much difference on students understanding on acids and bases.The results were also analyzed in terms of school independent variable. Table 4.48 shows the percentages of the students who gave correct answers on pre- and post-ABT questions:

Table 4.48 Summary of pre and post ABT results in terms of schools

	Pre-Test						Post-Test					
	Anatolian H. S.			Science H. S.			Anatolian H. S.			Science H. S.		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%
Item 1	146	138	94.5	146	139	95.2	146	144	98.6	146	145	99.3
Item 2	146	92	63	146	125	85.6	146	141	96.6	146	137	93.8
Item 3	146	106	72.6	146	116	79.5	146	134	91.8	146	132	90.4
Item 4	146	103	70.5	146	129	88.4	146	137	93.8	146	136	93.2

Table 4.48 Summary of pre and post ABT results in terms of schools (continued)

	Pre-Test						Post-Test					
	Anatolian H. S.			Science H. S.			Anatolian H. S.			Science H. S.		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%
Item 5	146	139	95.2	146	141	96.6	146	145	99.3	146	146	100
Item 6	146	99	67.8	146	129	88.4	146	142	97.3	146	137	93.8
Item 7	146	139	95.2	146	142	97.3	146	141	96.6	146	143	97.9
Item 8	146	144	98.6	146	142	97.3	146	146	100	146	144	98.6

Table 4.48 Summary of pre and post ABT results in terms of schools (continued)

	Pre-Test						Post-Test					
	Anatolian H. S.			Science H. S.			Anatolian H. S.			Science H. S.		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%
Item 9	146	121	82.9	146	128	87.7	146	140	95.9	146	140	95.9
Item 10	146	98	67.1	146	122	83.6	146	134	91.8	146	137	93.8
Item 11	146	134	91.8	146	142	97.3	146	145	99.3	146	146	100
Item 12	146	135	92.5	146	139	95.2	146	141	96.6	146	142	97.3

Table 4.48 Summary of pre and post ABT results in terms of schools (continued)

	Pre-Test						Post-Test					
	Anatolian H. S.			Science H. S.			Anatolian H. S.			Science H. S.		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Stude nts	Total # of questions answered correctly	%
Item 13	146	72	49.3	146	98	67.1	146	126	86.3	146	130	89
Item 14	146	8	5.5	146	27	18.5	146	78	53.4	146	103	70.5
Item 15	146	121	82.9	146	127	87	146	143	97.9	146	145	99.3
Item 16	146	44	34.1	146	40	27.4	146	82	56.2	146	94	64.4

Table 4.48 Summary of pre and post ABT results in terms of schools (continued)

	Pre-Test						Post-Test					
	Anatolian H. S.			Science H. S.			Anatolian H. S.			Science H. S.		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Stude nts	Total # of questions answered correctly	%
Item 17	146	106	72.6	146	123	84.2	146	132	90.4	146	140	95.9
Item 18	146	72	49.3	146	74	50.7	146	104	71.2	146	117	80.1
Item 19	146	80	54.8	146	82	56.2	146	132	90.4	146	140	95.9
Item 20	146	124	84.9	146	136	93.2	146	143	97.9	146	145	99.3

Table 4.48 Summary of pre and post ABT results in terms of schools (continued)

	Pre-Test						Post-Test					
	Anatolian H. S.			Science H. S.			Anatolian H. S.			Science H. S.		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Stude nts	Total # of questions answered correctly	%
Item 21	146	115	78.8	146	128	87.7	146	135	92.5	146	142	97.3
Item 22	146	37	25.3	146	97	66.4	146	99	67.8	146	126	86.3
Item 23	146	101	69.2	146	110	75.3	146	135	92.5	146	135	92.5
Item 24	146	52	35.6	146	117	80.1	146	122	83.6	146	130	89

Table 4.48 Summary of pre and post ABT results in terms of schools (continued)

	Pre-Test						Post-Test					
	Anatolian H. S.			Science H. S.			Anatolian H. S.			Science H. S.		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Students	Total # of questions answered correctly	%
Item 25	146	90	61.6	146	114	78.1	146	100	68.5	146	128	87.1
Item 26	146	85	58.2	146	124	84.9	146	128	87.7	146	134	91.8
Item 27	146	88	60.3	146	122	83.6	146	102	69.9	146	132	90.4
Item 28	146	33	22.6	146	58	39.7	146	92	63	146	98	67.1

Table 4.48 Summary of pre and post ABT results in terms of schools (continued)

	Pre-Test						Post-Test					
	Anatolian H. S.			Science H. S.			Anatolian H. S.			Science H. S.		
Item #	Total # of Students	Total # of students answered correctly	%	Total # of Students	Total # of questions answered correctly	%	Total # of Studen ts	Total # of questions answered correctly	%	Total # of Stude nts	Total # of questions answered correctly	%
Item 29	146	45	30.8	146	85	58.2	146	94	64.4	146	125	85.6
Item 30	146	13	8.9	146	45	30.8	146	101	69.2	146	113	77.4
Item 31	146	84	57.5	146	120	82.2	146	103	70.5	146	129	88.4
Item 32	146	84	57.5	146	107	73.3	146	137	93.8	146	140	95.9
Item 33	146	117	80.1	146	119	81.5	146	140	95.9	146	141	96.6

According to the Table 4.48, for the pre-ABT scores, the easiest question for the Anatolian high school students was item 8 whose percentage of correct answer was 98.6. For the science high school students, items 7, 8 and 11 were the easiest questions with the percentage of 97.2 for the correct answers. When the most difficult questions were analyzed, they were the item 14 and item 30 for Anatolian high school students with the percentages of 5.5 and 8.9. For the science high school students, the most difficult question was item 14 with the correct answer percentage of 18.5.

In terms of post-ABT scores, the easiest question was again item 8 for the Anatolian high school students that was 100 % correctly answered and for the science high school students; there were two questions that were answered correctly with a percentage of 100 %. They were items 5 and 11. The most difficult question was Item 14 and item 16 for the Anatolian high school group students, with the percentage of correct answers 53.4 and 56.2. Item 16 was the most difficult question for the science high school group students, with the percentage of 64.4 correct answers.

The most significant difference among the scores on the pre-ABT for the Anatolian and the science high school students was on item 24 with the difference of 44.5 % in the mean scores in the favor of science high school which means 44.5 % students in the science high school scored higher than the Anatolian high school students. For the post-ABT, this difference was on the item 29 with the difference of 21.2 % in the mean scores in the favor of science high schools. In other words, 21.2 % students in the science high school scored higher than the Anatolian high school students. Item 24 includes some mathematical skills to answer the question about acids and bases next to the misconception that "pH or pOH could not be equal to zero or fourteen" and item 29 was a question about salts with the misconception of "the salts of strong acids and bases does not always form neutral salts." Thus, it could be concluded that the students in the science high school students did not have the misconception related to item 24 as high rates as Anatolian high school students before the implementation and they also had less rates of students having the misconception related to item 29 after the implementation when compared to Anatolian high school students.

The smallest difference among the scores on the pre-ABT for the Anatolian and the science high school was on the item 1 with the value of 0.7; in other words, this question was answered correctly nearly with the same rate for both groups apart from the implementation. For the post-ABT, the smallest difference among the scores for the Anatolian and the science high schools was on the items 9, 17 and 23 with the value of 0 which means the students in both schools answered these questions correctly nearly with the same rate after the implementation.

An interesting result could be seen in the Table 4.48 was, for items 5 and 7 in pre-ABT, it was seen that the students in the Anatolian high school answered correctly with the highest rates. For the science high school students, items 7,8, and 11 were correctly answered with the highest rates. When the results of post-ABT were analyzed, the related items also answered correctly by most of the Anatolian and science high school students too. So, this questions may be the ones the students could easily guess or they already knew from the 8th grade so that they were all answering the questions correctly in pre and post-test.

Moreover, as mentioned before the items 13, 16, 19 and 28 included misconceptions that were designed for this study. When the students' results were analyzed according to Table 4.48, it could be concluded from the pre-ABT results that the students in both schools had these misconceptions before the implementation (they scored below 85%). When the post-ABT results were analyzed, it could be concluded that, the misconceptions of the Anatolian high school students were mainly remedied by the implementation for the questions item 13 and item 19 since they answered these questions correctly in the post-ABT with the percentage above 85%. It was also revealed the Anatolian high school students to still have the misconceptions for the item16 and item 28 since the correct answer response for these questions were lower than 85. When the science high school students' results were analyzed, the same table could be formed as in Anatolian high school. The change on percentage scores between pre-test and post-test for each item was presented in the Table 4.49 in terms of school independent variable:

Table 4.49 Change on percentage scores between pre & post-test in terms of schools

	Gain Score Percentage (Post-Test Score Percentage – Pre-Test Score Percentage)	
Item #	Anatolian High School (%)	Science High School (%)
Item 1	4,1	4,1
Item 2	33,6	8,2
Item 3	19,2	10,9
Item 4	23,3	4,8
Item 5	4,1	3,4
Item 6	29,5	5,4
Item 7	1,4	0,6
Item 8	1,4	1,3
Item 9	13	8,2
Item 10	24,7	10,2
Item 11	7,5	2,7
Item 12	4,1	2,1
Item 13	37	21,9
Item 14	47,9	52
Item 15	15	12,3
Item 16	26,1	37
Item 17	17,8	6,2
Item 18	21,9	29,4
Item 19	35,6	39,7
Item 20	13	6,1
Item 21	13,7	9,6
Item 22	42,5	19,9
Item 23	23,3	17,2
Item 24	48	8,9
Item 25	6,9	9
Item 26	29,5	6,9
Item 27	9,6	6,8

Table 4.49 Change on percentage scores between pre & post-test in terms of schools (continued)

	Gain Score Percentage (Post-Test Score Percentage – Pre-Test Score Percentage)	
Item #	Anatolian High School (%)	Science High School (%)
Item 28	40,4	27,4
Item 29	33,6	27,4
Item 30	60,3	46,6
Item 31	13	6,2
Item 32	36,3	22,6
Item 33	15,8	15,1

These scores in the Table 4.49 were calculated by subtracting the percentage of pre-ABT scores from the percentage of post-ABT scores directly. The most significant change on scores was on the item 30 for the Anatolian high school group. It was about neutralization reactions between weak base and strong acid and it was designed to detect the students' misconceptions. In other words, the students in the Anatolian high school understood the neutralization reactions between weak base and strong acid concepts better after the study. For science high school students, the most significant change in scores were seen in item 14 and item 30. Item 14 was about the anion and cation properties in terms of acids and bases and item 30 was again about neutralization reactions between weak base and strong acid. Both questions were designed to detect the students' misconceptions and according to these results, the students in the science high school showed the highest progress. In addition to these, the smallest score change percentage was on item 7 and 8 for the Anatolian high school students. Item 7 was about acids and bases from our daily life and their properties and item 8 was about finding pH and pOH values from the concentrations of hydrogen ion. For the science high school students, the smallest score change percentage were also on item 7 and item 8. So, it could be concluded that, for both schools, the implementation did not make much difference on students' learning of acids and bases for item 7 and item 8.

4.5.1 Interpreting the Results of Students' Misconceptions in ABT

Even if the total correct answers and the percentages were analyzed, as mentioned in Table 3.1, there were some questions specifically analysis the students' misconceptions. These questions were: items 1, 2, 3, 6, 7, 9, 10, 13, 14, 16, 19, 28, 30 and 33. In addition to these, even if direct misconceptions were not given, some items were also designed to overcome students' misconceptions (items 11, 12, 15, 18, 20, 24, 26, 27 and 29).

When experimental and control group students' responses were analyzed for ABT test in terms of misconceptions, remarkable differences were detected between the group answers for all these items. So, the students in the experimental group outperformed the test in terms of misconceptions with respect to the control group students. Even if this is the case, there were some questions that some of the students in the experimental group could be concluded to still have the misconceptions related to item 14, item 16 and item 30 since their percentages of the correct answer were below 85%.

Item 14 was a conceptual question not requiring mathematical calculation and it measured whether students had any misconceptions about the properties of the anions and cations in the structure of acids and bases. The related question, alternatives and the percentages of students' selection of alternatives in the post-ABT for item 14 were represented in Table 4.50:

Table 4.50 Percentages of students' selection of alternatives for item 14 in terms of group

About the anions and cations in the structures of acids and bases,

I. The anion that is the conjugate base of the weak acid shows basic property.
II. The anion that is the conjugate base of a strong acid shows neutral property.
III. The cations that form the structure of the strong bases show acidic property.

which conclusions are true?

A) Only III *B) I and II C) I and III D) II and III E) I, II and III I don't know

Percentages of Students' Responses in Groups (%)	A)	*B) Correct Alternative	C)	D)	E)	I don't know
CG (%)	20.7	22.1	19.4	4.6	33.2	-
EG (%)	-	75.5	1,2	0.2	23.1	-

As seen from the Table 4.50, while 75.5% of the experimental group students answered this question correctly, 22.1% of the control group students also answered this question correctly. However, 23.1% of experimental group students chose the alternative E as a correct answer, indicating that they still had the misconception that the cations that form the structure of the strong bases show acidic property (Seçken, 2010). Moreover majority of the control group students, 33.2 % also selected alternative E. Minority of students, 4.6 % control group students and 0.2 % experimental group students, selected alternative D who were also had the misconception of the cations that form the structure of the strong bases show acidic property and they also did not learn that the anion that is the conjugate base of the weak acid shows basic property.

Item 16 was another conceptual question not requiring mathematical calculation and measuring whether students had any misconceptions about the properties of oxoacids and halogen acids. The percentages of students' selection of alternatives in the post-ABT for item 16 were represented in Table 4.51:

Table 4.51 Percentages of students' selection of alternatives for item 16 in terms of group

About the strength of acids which one/ones are true?

I. The acid strength of the oxoacids that have same center atom is directly proportional to number of the oxygen atoms in their structures.

II. The acid strength of the oxoacids that have different center atom is found by comparing the electronegativity of the halogens in their structures.

III. To find the acid strength of halogen acids it was enough to control the bond strengths.

A) Only I *B) I and II C) II and III D) I and III E) I, II and III I don't know

Percentages of Students' Responses in Groups (%)	A)	*B) Correct Alternative	C)	D)	E)	I don't know
CG (%)	14,9	31	5.3	13.5	35.3	6
EG (%)	25,4	72.8	0.3	1.1	0.4	1.2

As seen from Table 4.51, while 72.8% of the experimental group students answered this question correctly, 31% of the control group students also answered this question correctly. However, 25.4 % of experimental group students chose the alternative A as a correct answer, indicating that they still did not understand that the acid strength of the oxoacids that have different center atom is found by comparing the electronegativity of the halogens in their structures. Moreover majority of the control group students, 35.3 % selected alternative E that shows they had the misconception that, for finding the acid strength of halogen acids it was enough to control the bond strengths. Minority of students, 5.3 % control group students and 0.3 % experimental group students, selected alternative C who also had the misconception of finding the acid strength of halogen acids it was enough to control the bond strengths and they also did not learn that the acid strength of the oxoacids that have different center atom is found by comparing the electronegativity of the halogens in their structures. Also there were 6 % of the control group student and 1.2% of the experimental group students that though they did not know the correct answer to this question which could be accepted as these students did not overcome the related misconception (alternative III) completely in both groups.

Item 30 was another conceptual question not requiring mathematical calculation and it measured whether students had any misconceptions about the properties of the anions and cations in the structure of acids and bases. The percentages of students' selection of alternatives in the post-ABT for item 30 were represented in Table 4.52:

Table 4.52 Percentages of students' selection of alternatives for item 30 in terms of group

A strong acid 100 ml, 0.1 M hydrochloric acid (HCl) solution was added to the 100 ml, 0.1 M weak base solution of ammonium hydroxide (NH_4OH). According to this information, which one/ones are true?

I. Since the base is weak, the neutralization does not occur completely.

II. These two substances neutralize each other completely.

III. The solution would be neutral.

IV. The environment would be acidic.

A) II and III *B) II and IV C) I and III D) I and IV E) III and IV I don't know

Percentages of Students' Responses in Groups (%)	A)	*B) Correct Alternative	C)	D)	E)	I don't know
CG (%)	0.4	40	16.3	42.1	1.2	-
EG (%)	-	82.3	-	19.7	-	1,2

As seen from this Table 4.52, while 82.3% of the experimental group students answered this question correctly, 40% of the control group students also answered this question correctly. However, 19.7 % of experimental group students chose the alternative D as a correct answer, indicating that they still had the misconception that since the base is weak, and the neutralization does not occur completely (Pınarbaşı, 2007). Moreover majority of the control group students, 42.1 % also selected alternative D. Minority of students, 0.4 % control group students and none of the experimental group students, selected alternative A who were also had the misconception of when acids and bases are equal in concentration and volume, the solution would be neutral (Yalçın, 2011). Also for the experimental group, there were 1.2 % of students that could not answer the question because they believe they had no idea about the answer. In other words, 1.2 % of the students did not overcome the related misconceptions (alternatives I and III) completely.

For other questions that were prepared to detect students' misconceptions and overcome them, the experimental group students answered the questions correctly with a percentage more than 85 %. So they were not examined in a detailed way in the study.

When science and Anatolian high school students' responses were analyzed for ABT test in terms of misconceptions, remarkable differences were detected between both schools' answers for all questions of ABT. Generally, it could be concluded that the students in the science high school outperformed the test in terms of misconceptions with respect to the Anatolian high school students. For the Anatolian high school students, the questions answered less than 85% for items 3,10,13,14,16,18,19,24, 26,27,28, 30 and 33 which were about misconceptions and items 14,16,18,28 and 30 were also answered less than 85% for the science high school students. This means that the students in both schools still might have misconceptions about acids and bases concepts in these questions even if science high school students remedied most of them. But since the schools were not separated into groups, this result could not be taken into consideration in terms of misconception since it is not possible to know if these results were because of control group or experimental group. So, for science and Anatolian high school students' responses to be analyzed for ABT test in terms of misconceptions, schools needed to be separated into control and experimental groups and the scores should then be compared (see Table 4.53):

Table 4.53 Students correct response percentages for post-ABT in terms of school and groups

Item #	Groups	Schools	
		Anatolian High School (% Correctly Answer)	Science High School (% Correctly Answer)
Item 1	CG	98.3	98.9
	EG	99	99.6
Item 2	CG	86.9	86.9
	EG	100	100
Item 3	CG	88	88.6
	EG	100	100
Item 4	CG	97.2	96
	EG	97.5	99.5
Item 5	CG	100	100
	EG	100	100
Item 6	CG	77	82.2
	EG	93.7	94.1
Item 7	CG	95.8	97.4
	EG	100	100
Item 8	CG	98	99.2
	EG	98.4	98.8
Item 9	CG	84	84.6
	EG	100	100
Item 10	CG	77.5	80.3
	EG	92.9	94.9
Item 11	CG	92.2	92.6
	EG	100	100
Item 12	CG	89	90.4
	EG	96	100
Item 13	CG	75	76.8
	EG	85.6	90

Table 4.53 Students correct response percentages for post-ABT in terms of school and groups (continued)

Item #	Groups	Schools	
		Anatolian High School (% Correctly Answer)	Science High School (% Correctly Answer)
Item 14	CG	21	23.2
	EG	69	82
Item 15	CG	84	87
	EG	98.2	99
Item 16	CG	29.8	32.2
	EG	70	75.6
Item 17	CG	86.8	88.4
	EG	93	93.4
Item 18	CG	67.4	67.8
	EG	83.3	84,1
Item 19	CG	71.8	73
	EG	85.6	90
Item 20	CG	94.3	95.7
	EG	100	100
Item 21	CG	87.8	86
	EG	99.1	99.5
Item 22	CG	66	65
	EG	85.2	87.6
Item 23	CG	80	81.4
	EG	91	91.4
Item 24	CG	67.9	70.1
	EG	84.9	89.3
Item 25	CG	71.8	70.2
	EG	89.7	90.1
Item 26	CG	75.2	76
	EG	80.5	90.5

Table 4.53 Students correct response percentages for post-ABT in terms of school and groups (continued)

Item #	Groups	Schools	
		Anatolian High School (% Correctly Answer)	Science High School (% Correctly Answer)
Item 27	CG	71.5	71.9
	EG	88	88.8
Item 28	CG	85.9	86.5
	EG	90.6	91.8
Item 29	CG	63.2	63.6
	EG	86	86.8
Item 30	CG	39.6	40.4
	EG	79.3	85.3
Item 31	CG	90	90.6
	EG	100	100
Item 32	CG	93.6	94
	EG	95	95.4
Item 33	CG	94.7	97.1
	EG	93.2	100

As it could be seen from the Table 4.53, experimental group in each school types for all items gained higher scores than the control groups. In addition to that, science high school students gather higher scores than the Anatolian high school students in all items except items 4, 21, 22 and 25. When these questions were analyzed, they were the mathematical questions that needed to be answered by the students. According to these results, it could be concluded that, in the Anatolian high school, the students were solving more problems related to acids and bases concepts which means their mathematical skills were developed more than science high school students.

When these results were analyzed in terms of misconceptions, for Anatolian high school students which were in the experimental group, the questions answered less than 85% for items 14, 16, 18, 24, 26 and 30 and for the control group, the items 6, 9, 10, 13, 14, 16, 18, 19, 24, 26, 27, 29 and 30. For the science high school students that were in the experimental group, the questions answered less than 85% for items 14,16 and 18 and for the control group, the items, 6, 9, 10, 13, 14, 16, 18, 19, 24, 26, 27, 29 and 30. Thus, it could be concluded that there were some questions that some of the students in both Anatolian and science high school's experimental groups still have the misconceptions since their percentages of the correct answer is below 85% The lowest percentages were seen in the items 14 and 16 for both schools and in each groups. So, only these items will be examined in a detailed format.

As mentioned above, item 14 was a conceptual question not requiring mathematical calculation and it measured whether students had any misconceptions about the properties of the anions and cations in the structure of acids and bases. The percentages of students' selection of alternatives in the post-ABT for item 14 were represented in Table 4.54:

Table 4.54 Percentages of students' selection of alternatives for item 14

About the anions and cations in the structures of acids and bases,

I. The anion that is the conjugate base of the weak acid shows basic property.

II. The anion that is the conjugate base of a strong acid shows neutral property.

III. The cations that form the structure of the strong bases show acidic property.

IV. which conclusions are true?

A) Only III *B) I and II C) I and III D) II and III E) I, II and III I don't know

Percentages of Students' Correct Responses for groups in schools (%)		A)	*B) Correct Alternative	C)	D)	E)	I don't know
Anatolian H. S.	CG (%)	12	21	9	14.2	43.8	-
Science H. S.	EG (%)	1	69	3.6	7	17.4	2
Anatolian H. S.	CG (%)	13	23.2	10.8	23	30	-
Science H. S.	EG (%)	1	82	4	6	7	-

As seen from this Table 4.54, for the Anatolian high school, while 69 % of the experimental group students answered this question correctly, 21 % of the control group students also answered this question correctly. However, 17.4 % of experimental group students chose the alternative E as a correct answer, indicating that they still had the misconception that the cations that form the structure of the strong bases show acidic property (Seçken, 2010). Moreover majority of the control group students, 43.8 % also selected alternative E. Minority of students, 9 % control group students selected alternative C and minority of students 1% of the experimental group selected alternative A who were also accepted to have the misconception of the cations that forms the structure of the strong bases show acidic property and they also did not learn that the anion that is the conjugate base of the weak acid shows basic property. For Anatolian high school experimental group, there were also 2% of the students that thought they did not know the answer of these questions which could also be accepted as the students that could not overcome the related misconception.

For science high school, while 82 % of the experimental group students answered this question correctly, 23.2 % of the control group students also answered this question correctly. However, 7 % of experimental group students chose the alternative E as a correct answer, indicating that a small number of students still had the misconception that the cations that form the structure of the strong bases show acidic property (Seçken, 2010). Moreover majority of the control group students, 30 % also selected alternative E. Minority of students, 10.8 % control group students selected alternative C and minority of students 1% of the experimental group selected alternative A who were also accepted to have the misconception of the cations that forms the structure of the strong bases show acidic property and they also did not learn that the anion that is the conjugate base of the weak acid shows basic property.

As mentioned before, item 16 was the other conceptual question not requiring mathematical calculation and measuring whether students had any misconceptions about the properties of oxoacids and halogen acids. The percentages of students' selection of alternatives in the post-ABT for item 16 were represented in Table 4.55:

Table 4.55 Percentages of students' selection of alternatives for item 16

About the strength of acids which one/ones are true?

I. The acid strength of the oxoacids that have same center atom is directly proportional to number of the oxygen atoms in their structures.

II. The acid strength of the oxoacids that have different center atom is found by comparing the electronegativity of the halogens in their structures.

III. To find the acid strength of halogen acids it was enough to control the bond strengths.

A) Only I *B) I and II C) II and III D) I and III E) I, II and III I don't know

Percentages of Students' Correct Responses for groups in schools (%)		A)	*B) Correct Alternative	C)	D)	E)	I don't know
Anatolian H. S.	CG (%)	3.9	29.8	7.7	21	37.6	-
Science H. S.	EG (%)	1.7	70	7.1	4.2	17	-
Anatolian H. S.	CG (%)	13.1	32.2	10,9	10.3	33.5	-
Science H. S.	EG (%)	2	75.6	5	5.4	12	-

As seen from Table 4.55, for the Anatolian high school, while 70 % of the experimental group students answered this question correctly, 29.8 % of the control group students also answered this question correctly. However, 17 % of experimental group students chose the alternative E as a correct answer, indicating that for finding the acid strength of halogen acids it was enough to control the bond strengths (This was the misconception put into the study by the researcher after taking the high school teachers' opinions about the study before beginning to the development of the ABT questions). Moreover majority of the control group students, 37.6 % also selected alternative E. Minority of students, 3.9 % control group students and 1.7 % of the experimental group selected alternative A, indicating that they still did not understand that the acid strength of the oxoacids that have different center atom is found by comparing the electronegativity of the halogens in their structures (This was the misconception put into the study by the researcher after taking the high school teachers' opinions about the study before beginning to the development of the ABT questions).

For science high school, while 75.6 % of the experimental group students answered this question correctly, 32.2 % of the control group students also answered this question correctly. However, 12 % of experimental group students chose the alternative E as a correct answer, , indicating that for finding the acid strength of halogen acids it was enough to control the bond strengths. Moreover majority of the control group students, 33.5 % also selected alternative E. Minority of students, 10.3 % control group students selected alternative D and minority of students 2% of the experimental group selected alternative A, indicating that they still did not understand that the acid strength of the oxoacids that have different center atom is found by comparing the electronegativity of the halogens in their structures.

In addition to these findings from the study, it could also be concluded that for control groups in Anatolian high school also overcome misconceptions in items 1, 2, 3, 7, 11, 12, 20, 28 and 33 and in science high school students in the control group overcome the misconceptions in items 1, 2, 3, 7, 11, 12, 15, 20, 28 and 33. This result is not surprising since the students in the control group also learn the concepts of acids and bases concepts in their lecture hours which may result in students' overcoming related misconceptions. In terms of experimental groups of both schools, more misconceptions were overcomed as expected. For Anatolian high school the items were 1, 2, 3, 6, 7, 9, 10, 11, 12, 13, 15, 19, 20, 27, 28, 29, and 33 whereas for science high school these items were 1, 2, 3, 6, 7, 9, 10, 11, 12, 13, 15, 19, 20, 24, 26, 27, 28, 29, 30 and 33 since they were all answered with a percentage above 85%. The reason of this high number of misconceptions being overcomed in the experimental groups could be accepted as the success of CBL instruction.

Moreover, the percentages for each alternative given for the items 13, 19 and 28 which include designed misconceptions were given in the Tables 4.56, 4.57, 4.58 except the item 16 since it was given above:

Table 4.56 Percentages of students' selection of alternatives for item 13

About the cations /anions that show acidic/basic properties in water;

I. The salt solutions that include the conjugate acids of the weak base show acidic properties

II. The cations easily take protons and show basic property.

III. The salt solutions of the conjugate bases of weak acids have higher hydrogen concentration

IV. Even if the metal cations that have small diameter with large charge do not give hydrogen ions to their aqueous solutions, their solutions were acidic.

V. Which one/ones is/are true?

A) I and II B) II and III C) III and IV *D) I and IV E) I, II and IV I don't know

Percentages of Students' Correct Responses for groups in schools (%)		A)	B)	C)	*D) Correct Alternative	E)	I don't know
Anatolian H. S.	CG (%)	2	10	9	75	1	3
Science H. S.	EG (%)	3	8	12	85.6	2	-
Anatolian H. S.	CG (%)	1.1	11.4	6.6	76.8	3.1	-
Science H. S.	EG (%)	1	3.3	5.7	90	-	-

Table 4.57 Percentages of students' selection of alternatives for item 19

Which one of the explanations below was/were true about weak acids?

I. The $[H_3O^+]$ ion concentration is equal to the weak acid's ion concentration that forms the solution.

II. In weak acids, as the initial concentration of the acid increases, its concentration in the equilibrium also increases.

III. In weak acids, as the initial concentration of the acids increases, the percentage of ionization decreases.

A) Only I B) I and II C) I and III *D) II and III E) I, II and III I don't know

Percentages of Students' Correct Responses for groups in schools (%)		A)	B)	C)	*D) Correct Alternative	E)	I don't know
Anatolian H.S.	CG (%)	6.2	7	7.3	71.8	6.1	1.6
Science H.S.	EG (%)	3.5	4.2	2.1	85.6	4.6	-
Anatolian H.S.	CG (%)	4.5	5.2	7.3	73	9	1
Science H.S.	EG (%)	-	2	-	90	8	-

Table 4.58 Percentages of students' selection of alternatives for item 28

Which one of the below was not the mission/usage area of the buffer solutions?

A. Providing the reactions to move in the wanted direction for biochemical reactions.

B. Make the pH of the blood constant.

C. Decreasing the side effects of the acids and bases that were produced/consumed in the chemical reaction made in laboratories.

D. Providing the acids to be removed from the kidneys.

E. Buffering the O_2 gas that was produced as a result of metabolic events. (Correct Response)

Percentages of Students' Correct Responses for groups in schools (%)		A)	B)	C)	D)	*E) Correct Alternative	I don't know
Anatolian H.S.	CG (%)	3.6	3.5	2.7	3	85.9	1.3
Science H.S.	EG (%)	4	2.4	3	-	90.6	-
Anatolian H.S.	CG (%)	4,9	3.6	1	4	86.5	-
Science H.S.	EG (%)	7	1.2	-	-	91.8	-

According to the related tables; for the Anatolian high school control group students, only the misconception in the item 28 was remedied with traditionally designed instruction. For the Anatolian high school experimental group students, the misconceptions in 13, 19 and 28 were remedied whereas the students still had misconceptions related to item 16 for the experimental group. What is important here was, the difference between the percentage of correct responses between the control and experimental group students for item 16: the control group students percentage of correct response to these question was 29.8 % whereas it was 70% for the experimental group. So, it could be concluded that the implementation was helpful for experimental group students to overcome the misconception in the item 16 when compared to control group students. For the science high school students, the students in the control group again remedied the misconception in the item 28 only and the experimental group students remedied the misconceptions in the items 13, 19 and 28 except the misconception in the item 16. Again what is important in this question was the difference between the percentage of correct responses between the control and experimental group students for item 16: the control group students percentage of correct response to these question was 32.2 % whereas it was 75.6% for the experimental group. So, it could be concluded that the implementation was helpful for experimental group students to overcome the misconception in the item 16 when compared to control group students. These results were a bit different from the 4.48 as expected. Since the differences were not analyzed by separating each school into groups before.

According to Table 4.48, students seemed to have misconceptions for the item 16 and item 28 for the Anatolian high school students. But in reality, the students in the Anatolian high school needed to be separated into control and experimental groups which revealed that control group students seemed to have misconceptions for the items 13, 16 and 19 and remedied the misconception in the item 28. When the experimental students of Anatolian high school were analyzed, the students still have misconceptions for item 16 and remedied all others. Again; according to Table 4.48 for the science high school students; students seemed to have misconceptions on the item 16 and item 28 as in Anatolian high school. But in reality, the students in the control group of science high school still had the misconceptions for items 13, 16 and 19 and remedied the misconception in the item 28. When the experimental students of science high school were analyzed, again the students still have misconceptions for item 16 and remedied all others as much as possible.

4.6 Results on Chemistry Motivation Questionnaire (CMQ)

Since each construct of motivation were put into the general MANCOVA analysis since the related variables should be analyzed all together as much as possible. Even if this was the case, the total pre and post CMQ scores and each constructs' descriptive statistics were given in Table 4.59 in terms of group independent variable:

Table 4.59 Comparison of total CMQ and its constructs in terms of students' mean scores in terms of group independent variable

CMQ Constructs	CG Mean	EG Mean	Total Mean
Pre-SE	30,63	30,71	30,67
Pre-ANX	14,79	14,05	14,41
Pre-GO	24,92	24,33	24,62
Pre-IM	18,77	18,97	18,87
Pre-SD	19,80	20,01	19,90
Total Score for Pre-CMQ	108,91	108,05	108,48
Post-SE	30,59	33,42	32,01
Post-ANX	18,75	20,02	19,39
Post-GO	24,51	28,16	26,35
Post-IM	18,74	20,56	19,65
Post-SD	19,43	21,23	20,34
Total Score for Post-CMQ	112,02	123,39	117,74

According to the Table 4.59, the most remarkable thing is that, before the implementation, the students in the control group had higher total scores in terms of motivation even if it was a small difference. After the implementation, the experimental group had higher total scores in terms of motivation and this time the difference is large. When the motivation of the students was analyzed it was seen that they were both increased whereas for experimental group there was an exponential increase in students' scores.

Before the implementation, students in the experimental scores had higher anxiety scores which means they had low anxiety in learning chemistry when compared to the experimental group students. In addition to that the students in the control group had higher goal-orientation scores which mean they were more focused to learning chemistry than the students in the experimental group.

After the implementation, in the control group, none of the constructs of motivation to learn chemistry had a larger mean score than in the experimental group. But it was an important point to be emphasized that even if the experimental group had higher mean scores in terms of motivational constructs, the total mean score for the control group after the implementation also seem to be increased. This increase was mainly because of the anxiety constructs' increase since all the other constructs of motivation mean scores were decreased when compared to the pre-test mean scores of them.

The total pre and post CMQ scores and each constructs' descriptive statistics were also analyzed in terms of school independent variable given in Table 4.60:

Table 4.60 Comparison of total CMQ and its constructs in terms of students' mean scores in terms of school independent variable

CMQ Constructs	Anatolian H.S. Mean	Science H.S. Mean	Total Mean
Pre-SE	30,35	31,03	30,6922
Pre-ANX	14,37	14,42	14,3962
Pre-GO	24,21	25,12	24,6644
Pre-IM	18,42	19,34	18,8828
Pre-SD	20,19	20,06	20,1267
Total Score for Pre-CMQ	107,17	109,79	108,4807
Post-SE	31,79	32,27	32,0342
Post-ANX	19,46	19,32	19,3904
Post-GO	26,03	26,79	26,4110
Post-IM	19,40	20,03	19,7158
Post-SD	20,36	20,44	20,4007
Total Score for Post-CMQ	116,79	118,70	117,7432

When the Table 4.61 was analyzed, generally it could be concluded that students' total motivation for both schools were increased and they were very close to each other after the implementation. Which means CBL instruction is not effective on students' total motivation scores when compared to traditionally designed instruction in terms of school independent variable.

Before the implementation, when the constructs of motivation were analyzed separately for the pre-CMQ, the science high school students scored a bit higher than the Anatolian high school students except the pre-self-determination (pre-SD) construct of motivation. When the post-CMQ constructs were analyzed separately, this time the science high school students scored a bit higher for each construct of CMQ except post-anxiety (post-ANX) construct. In other words, students in Anatolian high school gained a bit higher scores for the anxiety construct whereas students in science high school gained a bit higher scores in self-determination construct in the post-CMQ.

4.7 Results of the Classroom Observation Checklist

Observation checklist was mainly designed for treatment verification. It was filled by the researcher and one more observer in the Anatolian high school so that, more reliable checklists were collected; whereas it was filled alone by the researcher in the science high school for both control and experimental groups. The check list used for collecting different evidences for both groups; in the control group the implementation was examined in terms of its harmony with the traditionally designed instruction whereas in the experimental group, the implementation was examined in terms of its harmony with the case based learning instruction in terms of teachers' and students' role and the aims and objectives of the implementation.

Since the researcher tried to develop a simple and accurate checklist so that it would be possible to take notes according to the lectures progresses, there were 15 items in the checklist. In the Tables 4.62 and 4.63 the data according to the observation checklists were given in terms of Anatolian high school and science high school separately. Some items, related to activities in the observation checklist were only applicable to the experimental group (Item 4,5, 6, 7, 10, 12, 16, 17, 19, and 22) and coded as NA in the control group whereas item 20 is only applicable to control group and coded as NA in the experimental group.

At the end of the implication, the collected observation checklists collected from two observers were analyzed and 80% consistency was determined between both observers' decisions. Table 4.61 and Table 4.62 were giving the results of the analysis of the observation checklists collected from both schools.

Table 4.61 Table of observation checklist analysis collected from Anatolian high school

Control Group							
Item #	# of Observation	Excellent	Above Average	Average	Below Average	Poor	NA
1	54	54	0	0	0	0	0
2	54	35	13	3	1	2	0
3	54	38	10	4	1	1	0
4	54	0	0	0	0	0	54
5	54	0	0	0	0	0	54
6	54	0	0	0	0	0	54
7	54	0	0	0	0	0	54
8	54	4	2	1	1	20	26
9	54	50	3	1	1	0	0
10	54	0	0	0	0	0	54
11	54	23	14	6	3	8	0
12	54	0	0	0	0	0	54
13	54	44	7	2	0	1	0

Table 4.61 Table of observation checklist analysis collected from Anatolian high school (continued)

Control Group							
Item #	# of Observation	Excellent	Above Average	Average	Below Average	Poor	NA
14	54	16	12	9	11	6	0
15	54	31	14	2	2	5	0
16	54	0	0	0	0	0	54
17	54	0	0	0	0	0	54
18	54	27	9	3	2	3	10
19	54	0	0	0	0	0	54
20	54	48	4	1	0	1	0
21	54	33	11	3	0	0	7
22	54	0	0	0	0	0	54
23	54	52	1	0	1	0	0
24	54	43	0	5	4	2	0
25	54	37	15	2	0	0	0

Table 4.61 Table of observation checklist analysis collected from Anatolian high school (continued)

Experimental Group							
Item #	# of Observation	Excellent	Above Average	Average	Below Average	Poor	NA
1	53	53	0	0	0	0	0
2	53	50	3	0	0	0	0
3	53	51	1	1	0	0	0
4	53	53	0	0	0	0	0
5	53	53	0	0	0	0	0
6	53	53	0	0	0	0	0
7	53	53	0	0	0	0	0
8	53	50	2	1	0	0	0
9	53	41	2	2	3	5	0
10	53	53	0	0	0	0	0
11	53	48	5	1	0	0	0
12	53	30	2	3	1	0	17
13	53	53	0	0	0	0	0

Table 4.61 Table of observation checklist analysis collected from Anatolian high school (continued)

Experimental Group							
Item #	# of Observation	Excellent	Above Average	Average	Below Average	Poor	NA
14	53	53	0	0	0	0	0
15	53	52	1	0	0	0	0
16	53	30	6	0	0	0	17
17	53	5	1	0	0	0	47
18	53	51	1	0	1	0	0
19	53	51	2	0	0	0	0
20	53	0	0	0	0	0	53
21	53	49	2	2	0	0	0
22	53	52	1	0	0	0	0
23	53	8	10	2	4	5	24
24	53	53	0	0	0	0	0
25	53	47	4	2	0	0	0

Table 4.62 Table of observation checklist analysis collected from science high school

			Control Group				
Item #	# of Observation	Excellent	Above Average	Average	Below Average	Poor	NA
1	37	37	0	0	0	0	0
2	37	33	3	1	0	0	0
3	37	35	1	1	0	0	0
4	37	0	0	0	0	0	37
5	37	0	0	0	0	0	37
6	37	0	0	0	0	0	37
7	37	0	0	0	0	0	37
8	37	37	0	0	0	0	0
9	37	0	0	0	0	0	37
10	37	0	0	0	0	0	37
11	37	32	1	1	2	1	0
12	37	0	0	0	0	0	37
13	37	28	5	4	0	0	0

Table 4.62 Table of observation checklist analysis collected from science high school (continued)

Control Group							
Item #	# of Observation	Excellent	Above Average	Average	Below Average	Poor	NA
14	37	22	6	3	0	4	2
15	37	30	4	0	2	1	0
16	37	0	0	0	0	0	37
17	37	0	0	0	0	0	37
18	37	25	5	2	3	0	2
19	37	0	0	0	0	0	37
20	37	32	4	1	0	0	0
21	37	28	0	0	0	0	9
22	37	0	0	0	0	0	37
23	37	36	1	0	0	0	0
24	37	35	2	0	0	0	0
25	37	37	0	0	0	0	0

Table 4.62 Table of observation checklist analysis collected from science high school (continued)

Experimental Group							
Item #	# of Observation	Excellent	Above Average	Average	Below Average	Poor	NA
1	39	39	0	0	0	0	0
2	39	39	0	0	0	0	0
3	39	39	0	0	0	0	0
4	39	39	0	0	0	0	0
5	39	39	0	0	0	0	0
6	39	39	0	0	0	0	0
7	39	39	0	0	0	0	0
8	39	33	2	4	0	0	0
9	39	28	4	1	2	4	0
10	39	39	0	0	0	0	0
11	39	37	0	1	1	0	0
12	39	20	2	1	1	4	11
13	39	38	0	1	0	0	0

Table 4.62 Table of observation checklist analysis collected from science high school (continued)

Experimental Group							
Item #	# of Observation	Excellent	Above Average	Average	Below Average	Poor	NA
14	39	39	0	0	0	0	0
15	39	37	2	0	0	0	0
16	39	20	2	2	2	0	13
17	39	8	0	0	0	0	31
18	39	34	2	1	1	1	0
19	39	39	0	0	0	0	0
20	39	0	0	0	0	0	39
21	39	38	1	0	0	0	0
22	39	39	0	0	0	0	0
23	39	5	2	1	1	0	30
24	39	39	0	0	0	0	0
25	39	39	0	0	0	0	0

After both tables were analyzed, it could be concluded that the implementations of CBL and traditionally designed instruction were mainly provided in the study.

4.8 Results of the Students' Reflection Papers

In this study, at the end of each case, the students in the experimental group were given a reflection paper in which they found a chance to evaluate that day's lectures and the case as a whole. This reflection paper had two questions in it. The first question was asking the students what they learned and/or realized by the help of that case and the second question was asking the students what they expected to learn and/or what they thought to be absent in that case. Since there were eleven cases applied to the students, their reflections were coded for each case separately. Table 4.63 gives the results of this analysis:

Table 4.63 Results of the analysis of the reflection papers

Case	What They Learnt/Realized	What They Expected/What was Missing
Karate Kids	➢ I repeated the acids and bases general properties (27 %) ➢ I learnt that a theory could change in time when some other evidences found (22 %) ➢ I understand acids and bases better (16 %) ➢ My temporary knowledge become persistent with this case (13 %) ➢ I realized I was confusing the strength of acids and bases (11%) ➢ Nothing new. But I found a chance to repeat what I learned by having fun (9%) ➢ I realized I knew some acids and bases (2%)	There is nothing missing (45 %) If the reactions of acids and bases were included it would be better (25%) There may be some daily life acids and bases examples in the questions part (16%) ➢ A connection could be made with acids and bases in daily life (14%)
Acids and Bases in our Daily Life	➢ I learned that many foods I ate included acids and bases (28%) ➢ I realized even if I eat some acids and bases they might be harmful for my health (19%) ➢ I realized not all additives were harmful to human health (15%) ➢ I realized acids and bases are everywhere (13%) ➢ I learned that there were some acids making our blood basic and some base that make out blood acidic. (13%) ➢ I realized not all acids and bases were harmful to our health (7%) ➢ I did not know there were so much acidic and basic fruit and vegetables (5%)	There was nothing missing (54%) There may be some examples about the acids and bases that were harmful for our body (%22) The acids and bases were not only in our foods. I expected to see them in the table too. (%13) There may be more examples of basic fruits and vegetables. (%11)

Table 4.63 Results of the analysis of the reflection papers (continued)

Case	What They Learnt/Realized	What They Expected/What was Missing
Magical Mask	‣ I learned that acids and bases were defined many times by different researchers (39%) ‣ I learned the difference between law and theory (33 %) ‣ I learned Bronsted- Lowry acids and bases (17%) ‣ I realized how easy to learn Bronsted-Lowry acids and bases (9%) ‣ I learned science cannot be separated (2%)	The acid base theories should be explained a little more (53%) Lewis acid-base theory should be explained in a more detailed way (%29) There was nothing missing (18%)
Purification of Water	‣ I learned water during water purification there were many processes and acids and bases were used in them (21%) ‣ I repeated the pH and pOH concepts (19%) ‣ I realized I had some misconceptions about pH and pOH concepts (14%) ‣ I learned the concept of water hardness, what changes the water hardness and how to overcome this problem (13%) ‣ I learned amphoteric substances (11%) ‣ I realized pH is not only the measure of acidity and pOH is not only a measure of basicity (11%) ‣ I realized the acidic properties decrease as the pH is increased/ I realized the basic properties decrease as the pOH is increased (10%) ‣ I realized $CaCO_3$ is basic (1%)	There was nothing missing (90%) ‣ The ways to play with the pH values was missing (10%)

Table 4.63 Results of the analysis of the reflection papers (continued)

Case	What They Learnt/Realized	What They Expected/What was Missing
Pınar's Table Lamp	➢ I learned the connection between dissociation percentage, equilibrium constant, pH and pOH and conjugate acid-base pairs (31 %) ➢ I learned chemistry and physics are related to each other (%17) ➢ I learned the Ka and Kb and the dissociation ratio are directly proportional to each other (12%) ➢ I learned the electronegativity, chemical bonds and atomic radius relation with the acid/base strength (10%) ➢ I realized the conjugate acid/base of strong base/acid is weak and the conjugate acid/base of weak base/acid is strong (9%) ➢ I realized I have to study on this concept more (8%) ➢ I learned increasing the initial concentration of weak acid/base decreases the dissociation ratio (8%) ➢ I learned decreasing the initial concentration of a weak acid/base increases the percentage of ionization (5%)	There was nothing missing (76%) I expected from this case to include more examples (17%) I expected from this case to include less questions (7%)

Table 4.63 Results of the analysis of the reflection papers (continued)

Case	What They Learnt/Realized	What They Expected/What was Missing
Stomach's Enemy: Ulcer	‣ I learned the relation between the ulcer and acids and bases (24%) ‣ I learned new information about ulcer that would be helpful for my daily life (21%) ‣ I realized the indicators were not necessary for titration and neutralization reaction (16%) ‣ I learned the acids and bases give neutralization reaction even if they were not strong /did not have equal concentration (15%) ‣ I learned our stomach to be acidic and could be neutralized with basic drugs called antiacids (9%) ‣ I remembered the neutralization reactions and titration (6%) ‣ I learned the definition and the application of titration and indicator (5%) ‣ I realized the connection between biology and chemistry (4%)	I expected from this case to include less questions (57%) There was nothing missing (24%) The natural ways to cure ulcer should also be included (19%)
Making Fuel From Biodiesel	‣ I realized that in order to make biodiesel, acids and bases and titration were needed (29%) ‣ I learned the acid in the oil was a weak acid.(26%) ‣ I learned that the residual oil had more acid in its structure than pure oil. (23%) ‣ The ways to purify the residual oil (22%)	Nothing was missing (%75) I expected the whole process of making biodiesel with all its equations should be given (25%)

Table 4.63 Results of the analysis of the reflection papers (continued)

Case	What They Learnt/Realized	What They Expected/What was Missing
Selçuk and Water Boiler	‣ I learned how to remove lime from our water boiler (88%) ‣ I realized the reason of putting vinegar into the water boilers (10%) ‣ I learned that in the structure of lime dissolvent, there was acid (2%)	Nothing was missing (%95) There should be more examples for the concepts to be permanent (5%)
The Acid-Base Equilibrium in our Body	‣ I learned the buffer solutions (52%) ‣ I learned a new type of illness (24%) ‣ I realized the importance of buffer solutions for our body (11%) ‣ I learned different buffer solutions from daily life (7%) ‣ I learned types of buffer solutions in our body (6%)	The material was enough (53%) The mechanism behind the buffer solutions in our body should be given in detail (32%) The way how the drug was effecting the sick person should be explained. (9%) The harms of the related drug should be explained (6%)
Plants and Salts	‣ Different plants need different pH values (43%) ‣ I realized that the anions are acidic and cations are basic (28%) ‣ How the acidic, basic or neutral salts formed (19%)	Nothing was missing (100%)

When the results from students' reflections were analyzed, the cases could be accepted to be effective in students' understanding acids and bases concepts. However, there were small missing parts that needed to be revised for the future usage of these cases.

4.9 Summary of the Results

In this part, results of the study were summarized as follows:

- The mean scores of the students in the Anatolian high school (M=62.11) were lower than the students in the science high school (M=68.82) in terms of the pre-ABT scores
- The mean scores of the students in the Anatolian high school (M=30.35) were lower than the students in the science high school (M=31.03) in terms of the pre-SE scores.
- The mean scores of the students in the Anatolian high school (M=14.37) were lower than the students in the science high school (M=14.42) in terms of the pre-ANX scores.
- The mean scores of the students in the Anatolian high school (M=24.21) were lower than the students in the science high school (M=25.12) in terms of pre-GO scores.
- The mean scores of the students in the Anatolian high school (M=18.42) were lower than the students in the science high school (M=19.34) in terms of pre-IM scores.
- The mean scores of the students in the Anatolian high school (M=20.19) were higher than the students in the science high school (M=20.06) in terms of pre-SD scores.
- Since the pre-test scores of students in Anatolian and science high schools were very close to each other, these schools were accepted to be equal before the implementation.
- The mean scores of the students in the experimental group (M=65.46) were lower than the students in the control group (M=65.47) in terms of pre-ABT scores.

- The mean scores of the students in the experimental group (M=30.75) were higher than the students in the control group (M=30.64) in terms of pre-SE scores.
- The mean scores of the students in the experimental group (M=14.08) were lower than the students in the control group (M=14.72) in terms of pre-ANX scores.
- The mean scores of the students in the experimental group (M=24.73) were higher than the students in the control group (M=24.60) in terms of pre-GO scores.
- The mean scores of the students in the experimental group (M=18.90) was higher than the students in the control group (M=18.86) in terms of pre-IM scores.
- The mean scores of the students in the experimental group (M=20.30) were higher than the students in the control group (M=19.95) in terms of pre-SD scores.
- Since the pre-test scores of students in control and experimental groups were very close to each other, these groups were accepted to be equal before the implementation.
- The mean scores of the students in the Anatolian high school (M=80.03) were lower than the students in the science high school (M=83.75) in terms of post-ABT.
- The mean scores of the students in the Anatolian high school (M=31.79) were lower than the students in the science high school (M=32.27) in terms of post-SE.
- The mean scores of the students in the Anatolian high school (M=19.46) were higher than the students in the science high school (M=19.32) in terms of post-ANX.
- The mean scores of the students in the Anatolian high school (M=26.03) were lower than the students in the science high school (M=26.79) in terms of post-GO.
- The mean scores of the students in the Anatolian high school (M=19.40) were lower than the students in the science high school (M=20.03) in terms of post-IM.
- The mean scores of the students in the Anatolian high school (M=20.36) were lower than the students in the science high school (M=20.44) in terms of post-SD.
- The mean scores of the students in the experimental group (M=89.44) were higher than the students in the control group (M=74.23) in terms of post-ABT.

- The mean scores of the students in the experimental group (M=32.99) were higher than the students in the control group (M=31.07) in terms of post-SE.
- The mean scores of the students in the experimental group (M=19.61) were higher than the students in the control group (M=19.17) in terms of post-ANX.
- The mean scores of the students in the experimental group (M=27.80) were higher than the students in the control group (M=25.00) in terms of post-GO.
- The mean scores of the students in the experimental group (M=20.38) were higher than the students in the control group (M=19.04) in terms of post-IM.
- The mean scores of the students in the experimental group (M=20.92) were higher than the students in the control group (M=19.88) in terms of post-SD.
- For Anatolian high school, the mean scores of the students in the control group (M = 62) scored lower than the students in the experimental group (M = 62.22) in terms of pre-ABT.
- For Anatolian high school, the mean scores of the students in the control group (M = 30.77) scored higher than the students in the experimental group (M=29.96) in terms of pre-SE.
- For Anatolian high school, the mean scores of the students in the control group (M=15.24) scored higher than the students in the experimental group (M=13.55) in terms of pre-ANX.
- For Anatolian high school, the mean scores of the students in the control group (M= 24.54) scored higher than the students in the experimental group (23.89) in terms of pre-GO.
- For Anatolian high school, the mean scores of the students in the control group (M=18.62) scored higher than the students in the experimental group (M=18.24) in terms of pre-IM.
- For Anatolian high school, the mean scores of the students in the control group (M=20.04) scored lower than the students in the experimental group (M=20.33) in terms of pre-SD.

- Since the pre-test scores of both groups' students in Anatolian high schools were very close to each other, both groups were accepted to be equal before the implementation.
- For science high school, the mean scores of the students in the control group (M=68.80) scored lower than the students in the experimental group (M=68.83) in terms of pre-ABT.
- For science high school, the mean scores of the students in the control group (M=30.51) scored lower than the students in the experimental group (M=31.57) in terms of pre-SE.
- For science high school, the mean scores of the students in the control group (M=14.22) scored lower than the students in the experimental group (M=14.63) in terms of pre-ANX.
- For science high school, the mean scores of the students in the control group (M=24.66) scored lower than the students in the experimental group (M=25.60) in terms of pre-GO.
- For science high school, the mean scores of the students in the control group (M=19.09) scored lower than the students in the experimental group (M=19.60) in terms of pre-IM.
- For science high school, the mean scores of the students in the control group (M= 19.86) scored lower than the students in the experimental group (M=20.26) in terms of pre-SD.
- Since the pre-test scores of both groups' students in science high schools were very close to each other, both groups were accepted to be equal before the implementation.
- For Anatolian high school, the mean scores of the students in the control group (M= 71.93) scored lower than the students in the experimental group (M= 87.71) in terms of post-ABT.
- For Anatolian high school, the mean scores of the students in the control group (M= 30.72) scored lower than the students in the experimental group (M= 32.81) in terms of post-SE.

- For Anatolian high school, the mean scores of the students in the control group (M= 19.18) scored lower than the students in the experimental group (M= 19.72) in terms of post-ANX.
- For Anatolian high school, the mean scores of the students in the control group (M= 24.45) scored lower than the students in the experimental group (M= 27.52) in terms of post-GO.
- For Anatolian high school, the mean scores of the students in the control group (M= 18.73) scored lower than the students in the experimental group (M= 20.03) in terms of post-IM.
- For Anatolian high school, the mean scores of the students in the control group (M= 19.72) scored lower than the students in the experimental group (M= 20.97) in terms of post-SD.
- For science high school, the mean scores of the students in the control group (M= 76.45) scored lower than the students in the experimental group (M=91.25) in terms of post-ABT.
- For science high school, the mean scores of the students in the control group (M=31.41) scored lower than the students in the experimental group (M=33.17) in terms of post-SE.
- For science high school, the mean scores of the students in the control group (M=19.15) scored lower than the students in the experimental group (M=19.50) in terms of post-ANX.
- For science high school, the mean scores of the students in the control group (M=25.53) scored lower than the students in the experimental group (M=28.10) in terms of post-GO.
- For science high school, the mean scores of the students in the control group (M=19.34) scored lower than the students in the experimental group (M=20.75) in terms of post-IM.
- For science high school, the mean scores of the students in the control group (M=20.03) scored lower than the students in the experimental group (M=20.86) in terms of post-SD.

- Science high school control group students scored (M=68.80) higher than the Anatolian high school control group students (M=62) in terms of pre-ABT.
- Science high school control group students scored (M=30.51) lower than the Anatolian high school control group students (M=30.77) in terms of pre-SE.
- Science high school control group students scored (M=14.22) lower than the Anatolian high school control group students (M=15.24) in terms of pre-ANX.
- Science high school control group students scored (M=24.66) higher than the Anatolian high school control group students (M=25.54) in terms of pre-GO.
- Science high school control group students scored (M=19.09) higher than the Anatolian high school control group students (M=18.62) in terms of pre-IM.
- Science high school control group students scored (M=19.86) lower than the Anatolian high school control group students (M=20.04) in terms of pre-SD.
- Science high school experimental group students scored (M=68.83) higher than the Anatolian high school experimental group students (M=62.22) in terms of pre-ABT.
- Science high school experimental group students scored (M=31.57) higher than the Anatolian high school experimental group students (M=29.96) in terms of pre-SE.
- Science high school experimental group students scored (M=14.63) higher than the Anatolian high school experimental group students (M=13.55) in terms of pre-ANX.
- Science high school experimental group students scored (M=25.60) higher than the Anatolian high school experimental group students (M=23.89) in terms of pre-GO.
- Science high school experimental group students scored (M=19.60) higher than the Anatolian high school experimental group students (M=18.24) in terms of pre-IM.
- Science high school experimental group students scored (M=20.26) lower than the Anatolian high school experimental group students (M=20.33) in terms of pre-SD.

- Science high school control group students scored (M=76.45) higher than the Anatolian high school control group students (M=71.93) in terms of post-ABT.
- Science high school control group students scored (M=31.41) higher than the Anatolian high school control group students (M=30.72) in terms of post-SE.
- Science high school control group students scored (M=19.15) lower than the Anatolian high school control group students (M=19.18) in terms of post-ANX.
- Science high school control group students scored (M=25.53) higher than the Anatolian high school control group students (M=24.45) in terms of post-GO.
- Science high school control group students scored (M=19.34) higher than the Anatolian high school control group students (M=18.73) in terms of post-IM.
- Science high school control group students scored (M=20.03) higher than the Anatolian high school control group students (M=19.72) in terms of post-SD.
- Science high school experimental group students scored (M=91.25) higher than the Anatolian high school experimental group students (M=87.71) in terms of post-ABT.
- Science high school experimental group students scored (M=33.17) higher than the Anatolian high school experimental group students (M=32.81) in terms of post-SE.
- Science high school experimental group students scored (M=19.50) lower than the Anatolian high school experimental group students (M=19.72) in terms of post-ANX.
- Science high school experimental group students scored (M=28.10) higher than the Anatolian high school experimental group students (M=27.52) in terms of post-GO.
- Science high school experimental group students scored (M=20.75) higher than the Anatolian high school experimental group students (M=20.03) in terms of post-IM.
- Science high school experimental group students scored (M=20.86) lower than the Anatolian high school experimental group students (M=20.97) in terms of post-SD.

- There was a normal distribution for all the variables in the descriptive statistics in terms of school independent variable.
- There was a normal distribution for all the variables in the descriptive statistics in terms of group independent variable.
- Pre-ABT, pre-SE, pre-ANX, pre-GO, pre-IM and pre-SD were determined as covariates because they were continuous variables that were significantly correlated with the dependent variables, and show moderate correlation among each other at most.
- The assumptions of MANCOVA, cell size, independence of observations, outliers, normality, multicollinearity, and linearity, homogeneity of variances and homogeneity of regression were all met.
- There was a statistically significant difference between teaching methods when taking CBL and traditionally designed instruction into account on the population mean of the collective dependent variables of eleventh grade students' post-test scores of Acids and Bases Test (post-ABT) and motivation to learn chemistry post-test scores of each construct (post-CMQ constructs) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled. (Wilks' λ=0.35, F (6,277) = 85.782, p=0.000).
- There was not found any statistically significant mean difference between Anatolian and science high schools on the population means of the collective dependent variables of eleventh grade students' post-test scores of Acids and Bases Test (post-ABT) and motivation to learn chemistry post-test scores of each construct (post-CMQ constructs) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled (Wilk's Λ = 0.984, F (6, 277) = 0.738).
- There was not found any statistically significant interaction between the treatment and school types on the population means of collective dependent variables of eleventh grade students' post-test scores of Acids and Bases Test (post-ABT) and motivation to learn chemistry post-test scores of each construct (post-CMQ constructs) and motivation to learn chemistry post-test scores of each construct

when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled (Wilk's $\Lambda = 0.981$, F (6, 277) = 0.896, p = 0.498).

- There was a statistically significant difference between the students taught via CBL instruction and traditionally designed instruction on the population means of the post-test scores of Acids and Bases Test (post-ABT) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled (F (1,282) = 501.284, p = 0.00).
- There was not found any statistically significant difference between Anatolian and science high school on the population means of the post-test scores of Acids and Bases Test (post-ABT) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled (F (1,282) =0.945, p = 0.332).
- There was not found any statistically significant interaction between the treatment and school types on the population means of the post-test scores of Acids and Bases Test (post-ABT) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled (*F*(1,282) = 0.417, p = 0.519).
- There was a statistically significant difference between students taught via CBL instruction and traditionally designed instruction on the population means of the post-test scores of the self-efficacy construct of motivation to learn chemistry questionnaire (post-SE) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled (F (1,282) =25.305, p=0.000)
- There was not found any statistically significant difference between Anatolian and science high schools on the population means of the post-test scores of the students' self-efficacy construct of motivation to learn chemistry questionnaire (post-SE) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled (F (1,282) = 0,336, p = 0.562).

- There was a statistically significant interaction between the treatment and school types on the population means of the post-test scores of the students' self-efficacy construct of motivation to learn chemistry questionnaire (post-SE) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled (F (1,282) = 5.379, p = 0.021).
- There was a statistically significant difference between students taught via CBL instruction and traditionally designed instruction on the population means of the post-test scores of the anxiety construct of motivation to learn chemistry questionnaire (post-ANX) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled (F (1,282) = 1.663, p = 008).
- There was not found any statistically significant difference between Anatolian and science high school on the population means of the post-test scores of the students' anxiety construct of motivation to learn chemistry questionnaire (post-ANX) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled (F (1,282) = 3,094, p = 0.080).
- There was not found any statistically significant interaction between treatment and school types on the population means of the post-test scores of the students' anxiety construct of motivation to learn chemistry questionnaire (post-ANX) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled (F (1,282) = 1,577, p = 0.210).
- There was a statistically significant difference between of students taught via CBL instruction and traditionally designed instruction on the population means of the post-test scores of the goal-orientation construct of motivation to learn chemistry questionnaire (post-GO) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled (F (1,282) = 39,328, p = 0.000).

- There was not found any statistically significant difference between Anatolian and science high school on the population means of the post-test scores of the students' goal-orientation construct of motivation to learn chemistry questionnaire (post-GO) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled ($F_{(1,282)} = 0,336$, $p = 0.562$).
- There was a statistically significant interaction between treatment and school types on the population means of the post-test scores of the students' goal-orientation construct of motivation to learn chemistry questionnaire (post-GO) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled ($F_{(1,282)} = 5.774$ $p = 0.017$).
- There was a statistically significant difference between of students taught via CBL instruction and traditionally designed instruction on the population means of the post-test scores of the intrinsic motivation construct of motivation to learn chemistry questionnaire (post-IM) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled ($F_{(1,282)} = 23,340$, $p = 0.000$).
- There was not found any statistically significant difference between Anatolian and science high school on the population means of the post-test scores of the students' intrinsic motivation construct of motivation to learn chemistry questionnaire (post-IM) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled ($F_{(1,282)} = 0.219$ $p = 0.640$).
- There was not found any statistically significant interaction between treatment and school types on the population means of the post-test scores of the students' intrinsic motivation construct of motivation to learn chemistry questionnaire (post-IM) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled ($F_{(1,282)} = 1,530$, $p = 0.217$).

- There was a statistically significant difference between of students taught via CBL instruction and traditionally designed instruction on the population means of the post-test scores of the self-determination construct of motivation to learn chemistry questionnaire (post-SD) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled ($F(1,282) = 14{,}359$, $p = 0.000$).
- There was not found any statistically significant difference between Anatolian and science high school on the population means of the post-test scores of the students' self-determination construct of motivation to learn chemistry questionnaire (post-SD) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled ($F(1,282) = 1.030$, $p = 0.311$).
- There was not found any statistically significant interaction between treatment and school types on the population means of the post-test scores of the students' self-determination construct of motivation to learn chemistry questionnaire (post-SD) when the effects of students' previous learning on acids and bases concepts and their previous motivation to learn chemistry were controlled ($F(1,282) = 3.560$, $p = 0.06$).
- Pre-ABT was found to affect students' post-ABT scores significantly.
- Pre-SE was found to affect students' post-ABT, post-ANX, post-GO, post-IM and post-SD scores significantly.
- Pre-ANX was found to affect students' post-ABT, post-SE, post-ANX, post-GO, post-IM and post-SD scores significantly.
- Pre-GO was found to affect students' post-SE, post-GO and post-IM scores.
- Pre-IM was found to affect students' post-ABT, post-SE, post-ANX, post-IM and post-SD scores significantly.
- Pre-SD was found to affect students' post-ANX, post-IM and post-SD scores significantly.
- The results of the researcher's notes showed that students had fun, improved their understanding, became more active and motivated to learn chemistry in the experimental groups.

- The results of the researcher's notes showed that teaching the aspects of NOS made students more active and motivated to learn chemistry.
- The results of the researcher's notes showed that interdisciplinary teaching attracted students' attention more.
- The results of post-ABT revealed evidence about the success of CBL instruction on remedying students' misconceptions when compared to traditionally designed instruction.
- The results of the post-ABT revealed some new misconceptions that could make a contribution to the literature.
- The results of classroom observation checklist revealed evidence about the CBL implementation for the experimental groups and it revealed evidence about traditionally designed instruction implementation for the control groups.
- The results of the reflection papers which were filled by the experimental group students showed the positive effect of the cases used in this study on students' realization and their learning that leads improved understanding on the related acids and bases concepts.
- The results of the reflection papers showed evidence about the positive effects of the cases applied in this study on detecting students' misconceptions and improving students' own awareness of their misconceptions.

4.10 Conclusion of the Study

In this part, the conclusion about this study was given:

- Case based learning (CBL) instruction was more effective than traditionally designed instruction in terms of students' understanding of acids and bases concepts.
- CBL instruction was more effective than traditionally designed instruction in terms of self-efficacy, anxiety, goal-orientation, intrinsic motivation and self-determination constructs of motivation.
- CBL instruction is more effective than traditionally designed instruction in terms of determining and overcoming students' misconceptions.

- Neither CBL nor traditionally designed instruction had a statistically significant effect on different school types in increasing students' understanding of acids and bases concepts. However, CBL is effective than traditionally designed instruction regardless of the school types students attend.
- Neither CBL nor traditionally designed instruction had a statistically significant effect on different school types in increasing students' self-efficacy, anxiety, goal-orientation, intrinsic motivation and self-determination constructs of motivation.

CHAPTER 5

DISCUSSION, IMPLEMENTATIONS AND RECOMMENDATIONS

In this chapter there were five sections beginning with a general discussion of the study and then the interpretation of the results were introduced. Next, the generalization of the study was presented. Afterwards, a conclusion that was followed by the implications of the results was given. And lastly, suggestions of this study for future research were introduced.

5.1 Discussion of the Results

5.1.1 General Overview to the Study

First of all, in this study there were two main aims to be studied: first, it was to investigate the effect of CBL instruction and school on 11th grade high school students' understanding of acids and bases concepts when compared to traditionally designed instruction and second, it was to investigate the effect of CBL instruction and school on 11th grade high school students' motivation to learn chemistry (self-efficacy, anxiety, goal-orientation, intrinsic motivation and self-determination) compared to traditionally designed instruction. In other words, this study was designed to improve students' will to learn chemistry by trying to improve their motivation to learn chemistry and developing their conceptual understanding in chemistry that results in an increase in their achievement by using CBL instruction that allows students to engage in minds-on cases, to become actively participating during learning process, to work as groups that leads to collaborative learning and social skills and to form discussion environments which could improve students' self-confidence accordingly that were all embedded in the cases prepared as a part of real-life events.

The main reason for selecting the acid-base unit of chemistry was because of its being very difficult for students to understand since it was found to be complicated and abstract for students (Çetin-Dindar, 2010). The reason for student s' thinking this way might be because, even if many schools have technological instruments or new teaching strategies for teachers and students to use, they are not getting help from the technology to learn new things and they are not going to laboratories to make what they learned concrete because of several reasons like teachers concern about timing, their fear of students not being interested or loosing classroom management if they apply these new technologies or new teaching strategies or simply lack of knowledge about the improving technology. There may be different explanations to this situation but since this was the case, it could be concluded that there was a need for students and teachers to use new teaching strategies and technologies that aimed to improve student' understanding so that the problems in learning for students could more easily be remedied.

Because of the related explanations above, some additional purposes were added to the study unofficially which were teaching new strategies to teachers so that they could integrate them into their lectures for the future, helping the students to learn the difficult concepts in a more easy and funny way, overcoming the teachers beliefs about time restrictions which prevent them from learning new technologies or teaching strategies, changing some students' negative feelings about chemistry and making the students' as active as possible during the lectures.

In this study, the experimental group students spent their classes on cases that included related questions about the cases and students were actively searching for the related logical explanations to the questions from the given information in the cases, sharing their ideas with their group mates, discussing their findings with all class and trying to find the correct solution for each case all together during the implementation process whereas the students in the control group were given the related concepts directly by their teacher and then solved more mathematical problems about acids and bases concepts when compared to the students in the experimental group.

In addition to these, two different tests were administered to both experimental and control group students as pre- and post-test: Acid Base Test (ABT) and chemistry motivation questionnaire (CMQ) composed of five subscales (self-efficacy, anxiety, goal-orientation, intrinsic motivation and self-determination). The related data were analyzed by MANCOVA analysis and follow-up ANOVA analysis as a double check by using SPSS.

5.1.2 Discussion Related to the Results from the ABT

At the beginning of the instruction, students' prior knowledge on acids and bases concepts was assessed by ABT (pre-ABT) to determine whether there was a significant mean difference between experimental and control group students (see Table 4.5) and to determine whether there was a significant mean difference between Anatolian and science high school students (see Table 4.7) in terms of their previous conceptions of acids and bases.

When the descriptive statistics for the pre-ABT test results were compared in terms of the control and experimental groups, it was revealed that they scored very close to each other. In other words, there was no mean difference between experimental and control group students in terms of their pre-existing knowledge about acids and bases concepts (pre-ABT) prior to treatment whereas students in two schools were a bit different in terms of their pre-existing knowledge about acid-base concepts in the favor of science high school. Also, the partial eta squared value of 0.19, which means that 19 % of the variance of the dependent variable was associated with school, evidenced the very large effect of school on the scores of pre-ABT.

The reason of the students doing better in the science high school might be because of their being more willing to learn science and mathematics so that they were studying harder. Another reason may be because of having some private lectures on chemistry so that they might already knew the concepts on acids and bases or maybe they could remember what they learned in the 8th grade better when compared to Anatolian high school students.

However, even if there was a small difference between students in terms of school types, they were accepted as equal to each other for this study after controlling the groups' mean scores together with the schools they were in and finding out the students in both groups of both schools had very close scores from the pre-ABT.

When the descriptive statistics results for post-ABT were compared in terms of group independent variable, it was found that the scores of the students in the experimental group were higher than the scores of the students in the control group with respect to their understanding of acids and bases unit of chemistry (see table 4.5). Actually, there was an increase for both groups in terms of the number of the correct answers in the post-test, but this increase was much higher in the experimental group which could be accepted as a proof for CBL instruction to be more effective when compared to traditionally designed instruction in terms of students understanding of acids and bases concepts.

When the descriptive statistics results for post-ABT were compared in terms of school independent variable, even if the mean scores were higher in the favor of science high school, the difference between Anatolian and science high school mean scores was lowered (see table 4.7). These results may be provided by the implementation applied in this study which could be accepted as an evidence for CBL instruction to be effective on students' understanding of acids and bases concepts regardless of school types.

After the descriptive statistics were analyzed, the MANCOVA analysis was conducted to gather inferential statistical results. In terms of ABT scores, this analysis revealed that there was a significant mean difference between experimental and control group students with respect to the implementation effect on students' understanding of concepts of acids and bases after instruction in both science and Anatolian high schools. In other words, the conclusions done according to the descriptive statistics about CBL being effective on students' understanding of acids and bases concepts was also found to be statistically significant. A study conducted by Yalçınkaya (2010) revealed a similar result: CBL instruction was found to be more effective in terms of enhancing high school students' understanding of gas concept when compared to traditionally designed instruction. Sendur (2011) also found CBL instruction to produce greater success for understanding of gas laws when compared to traditionally designed instruction. Another study conducted by Çam & Geban (2013) also revealed CBL instruction to be more successful for solubility equilibrium concepts when compared to traditionally designed instruction in terms of students' understanding. Thus, from a theoretical perspective, the findings of this study were consistent with the literature that the use of CBL instruction being superior to traditionally designed instruction in terms of students' understanding and performance skills (see also Çakır, 2002; Mayo, 2004; Rybarczyk et al., 2007; Saral 2008).

The reasons for the success of implementation might be because of motivating students (Prince & Felder, 2006; King, Lawrence & MacKinnon, 2014; Yalçınkaya, 2010) by introducing them interesting and fun cases, taking their attention more by engaging them into learning process actively and real-life situations (Yalçınkaya, 2010), improving their social skills (King, Lawrence & MacKinnon, 2014) and self-confidence (Patterson, 2006) by involving them into discussion environments (Certo, 2011; Topala, 2014), identifying the misconceptions that students had and working to overcome these misconceptions during the instructions (Cliff, 2006; Çam & Geban, 2013) or might be because of developing conceptual framework and integration of metacognitive approaches into learning (Gallucci, 2006).

Moreover, the MANCOVA analysis revealed CBL instruction to be effective regardless of school type. In other words, students did not differ in terms of their understanding of acids and bases concepts according to the school they attend, Anatolian or science high school (See Table 4.24) This result could also very obvious when the descriptive statistics tables, Table 4.9 and Table 4.10, were compared in terms of ABT scores of control and experimental group students in both schools and it could be double checked by the follow-up ANCOVA results of the "null hypothesis 2". Actually, this result was a good point since, CBL instruction does not separate students according to some properties like school type or it was not favoring any characteristic of students. Instead, it was effective for all types of students it was implemented. Thus, CBL was found to be effective in terms of students' understanding of acids and bases concepts when compared to traditionally designed instruction regardless of school type which was a crucial finding to be added to the literature.

5.1.3 Discussion Related to Students' Misconceptions

In this study, there were also cases that included some questions which aimed to detect the students' misconceptions and overcome them (see Table 3.1). Also, there was a presentation prepared to cover up each misconception that was mentioned during the study as a summary. In addition to these, the ABT also included many questions for the same reason (see Table 4. 54). After the implication and the presentation completed in the experimental group, both groups were administered the ABT as a posttest. When the results of ABT were checked, it could be seen that many misconceptions were remedied by the students in the experimental groups when compared to control groups in both schools. In other words, control group students still found to have more misconceptions. For example, when the questions related to students' misconceptions were analyzed, many students in the control group seemed to believe "a solution that had the pOH = 0 could not be prepared" (Kariper, 2011; Morgil et al, 2002) or many of them still believe "when a strong acid gives reaction with a strong base, all solutions formed from these reaction would have a pH=7" (Ayas & Demircioğlu, 2002; Demircioğlu, Özmen & Ayas, 2002; Schmidt, 1991).

Even if the students in the control group had more misconceptions when compared to experimental group students, it was found that some students had misconceptions on some acid-base concepts even after the CBL instruction applied in experimental group too. For example, few students in experimental group still had misconceptions like "when a strong acid and a weak base are put into a reaction with equal amounts, they could not neutralize each other completely" (Pınarbaşı, 2007) which was a similar finding to Schmidt (1991), and Ross & Munby (1991) since in these studies, it was emphasized that the concepts of neutralization and neutrality were misunderstood by most of the students. The reason of this misconception was also mentioned in their studies as students being failed to realize the central role of water in neutralization reactions.

In addition to these, although literature findings indicated that students have misconceptions of "Acids turn litmus paper to purple" (Cros et al., 1986; Cros et al., 1988; Demircioğlu et al., 2005; Hand & Treagust, 1991; Morgil et al., 2002; Nakhleh

& Krajcik, 1994; Ozmen & Demircioğlu, 2002) and "Bases turn litmus paper to red" (Cros et al., 1986; Cros et al., 1988; Demircioğlu et al., 2005; Hand & Treagust, 1991; Morgil et al., 2002; Nakhleh & Krajcik, 1994; Ozmen & Demircioğlu, 2002), the results of this study according to pre-ABT and post-ABT, showed that a few of the experimental and control group students had these misconceptions. These misconceptions and the results were given in the chapter four in a detailed way (see Table 4.53)

Moreover, there were also some misconceptions formed for this study that were parallel with the literature (e.g. Çetingül & Geban, 2011; Nakhleh & Krajcik, 1994; Ozmen & Demircioğlu, 2002; Pınarbaşı, 2011; Yalçın, 2011), according to textbooks (e.g. Atalay, 2011; Dursun et al., 2012; Hill, Kolb & McCreary, 2009; Kaya, 2012) and with the help of the teachers' experience that took a part in the study. According to pre-ABT results, there were new misconceptions detected in the students before the implementation:

- The salt solutions that include the conjugate bases of weak acids have higher hydrogen concentration.
- It was enough to check the strength of the bonds in order to find the halogen acids' strength.
- The [H_3O^+] ion concentration is equal to the weak acid's ion concentration that forms the solution.
- Stippling O_2 that was formed after metabolical events is one of the missions of the buffer solutions.

After the implementation, only the misconception "stippling O_2 that was formed after metabolical events is one of the missions of the buffer solutions." was remedied for the control group students in both schools. Whereas, for the experimental groups, all the misconceptions except "it was enough to check the strength of the bonds in order to find the halogen acids' strength" in the item 16 was not remedied as much as expected even if the students' in both schools percentage of correct responses were much higher than the control group students. One of the reason of not overcoming this misconception in experimental group might be because of the teachers' not getting enough feedback from the students' about the related concept during explanation of it or students were not being attracted to the lecture by the teacher so that they did not listen to the explanation. One other reason of detecting this misconception might be because of students' lack of knowledge on chemical bonds (Tan & Treagust, 1999), the bond strength or halogen acids even after the CBL instruction. The students might also have difficulty in understanding acid-base strength because of its abstract nature. Another reason of this result may be because of not having any direct cases designed to cover the related misconception in this study because of time limitations or another reason might simply be the misconceptions being persistent to change (Anderson & Smith, 1987; Yılmazoğlu, 2010; Wandersee et al., 1994).

Furthermore, when the post-ABT scores and the gain scores were examined, students in experimental group outperformed these test in terms of understanding and overcoming the misconceptions about the concepts of acids and bases. However, there were some misconceptions related to acids and bases concepts that were also determined in some of the experimental group students after CBL instruction since these students checked the wrong alternatives that include misconceptions in the test.

The reason for not erasing all misconceptions from experimental group students' minds may be because of their being are persistent to use misconceptions even after instruction designed to address misconceptions (Anderson & Smith, 1987; Champagne, Gunstone, & Klopfer, 1985; Çetingül &Geban, 2011; Fisher, 1985; Wandersee et al., 1994). Also some researchers believed many of the misconceptions would never be remedied from students' minds (Wandersee et al., 1994) no matter how hard it was tried. Another important reason for not erasing all of the misconceptions from students' minds may be because of the Turkish educational system. In this system, many of the teacher educating faculties do not mention the importance of misconceptions or make the pre-service teachers come face to face with their own misconceptions to remedy them. For this reason, when the teachers were graduated from the universities and begin teaching, they teach their own misconceptions to their student as expected. In addition to these, since it was difficult for students in Turkey to win the university entrance exam, the students took private courses one by one or as a small group or they go to special courses given in private foundations called “etüt merkezi” or a more crowded one “dershane” which were very close or same to general school structures in terms of classroom environments, teaching methods (that is traditional) and the curriculum they followed. Each solution students apply include this type of teachers mentioned above that already had their own misconceptions. These teachers also cause the students to have misconceptions so that, a study that took twelve weeks was not as much effective as expected to overcome students’ misconceptions totally because other educational courses or foundations (like dershane or etüt merkezi) may have the possibility to promote them.

There were also some misconceptions in the cases that the students came face to face with and which were not found in the Acids and Bases Test (ABT). These questions were directly asked during the lecture hours and discussed by the students in their groups and also with their classes. In addition to that, a presentation prepared for the students to make a summary of the misconceptions related to acids and bases concepts was applied. In this presentation, the students were given as much misconceptions as possible parallel to what they learned. In this presentation, there were also some misconceptions formed for the study under the light of the related literature and the teachers’ experiences of this study. Even if the misconceptions in the cases and the misconceptions in the presentation were tried to be studied during the study, there were not any instrument developed for evaluating these misconceptions instead of the observation notes of the researcher. According to these notes, some misconceptions were also detected in the students during the study (the misconceptions in the cases) which were tried to be remedied by the teacher in the lecture hours. These misconceptions were:

- When the indicators are not used, titrations could not be conducted.
- When weak acid and strong base were mixed equally the pH of the surrounding never becomes 7.
- Strong acid- strong base, strong acid - weak base, weak acid - strong base, weak acid - weak base titrations were always carried out in the same way.
- A buffer solution could be prepared by using only acid/only base.

According to the researcher's notes, to give an example to the students' reasoning behind these misconceptions, when their teachers asked the reason why they thought indicators was a must for titration reactions, they simply answer that "it was taught us as in a titration reaction we got help from the indicators to detect the equivalence point". Thus it can be concluded that teachers should have some of these misconceptions or their teaching might cause students to have the misconceptions. For this reason, it can be concluded that teachers were the sources of some misconceptions. Students also show their textbooks as a proof to their opinions according to the researchers' notes. Thus, another source for students' misconceptions should be accepted as the textbooks.

Moreover, according to the researchers' notes, some misconceptions were found to be remedied by the students after the implementation since the presentation activity was conducted after the implementation and next to additional misconceptions related to the acids and bases, it also covered the misconceptions found in the Acids and Bases Test and cases. According to researchers' notes, students remedied the misconceptions in them. However, since there were additional misconceptions related to acids and bases concepts, another misconception was detected during the presentation activity conducted after the implementation. This misconception was:

- When a strong acid and strong base gives a neutralization reaction, the salts formed after the reaction shows acidic/basic or neutral properties according to the acids/bases' initial proportions in the reaction.

According to the researcher's notes, to give an example to the students' reasoning for their misconception, they answered "because I do not know the proportions of them before the reaction. Maybe the salt should be basic if the base solution is more than acid solution". This was an evidence for students' confusing their knowledge about weak acids and bases with the strong acids and bases. The reason of this answer might be because there were no questions related to this misconception in the cases or in the ABT. For this reason, they tried to link what they learned before with this information. Even if the teachers were informed to talk about the related misconceptions if they had time, it could be seen that students could not remedied the related misconception.

To conclude, this study results showed that CBL instruction was also effective for determining students' misconceptions and remedying them as much as possible. In addition to this result, by the help of this study, some new misconceptions were revealed in students and many of them were remedied again with CBL instruction. However, these misconceptions should be tested with different samples or with different teaching methods to control whether they were still detected in students or not. Because, only testing these misconceptions in different circumstances should be used as a proof for this study not to be the source of the related misconceptions. In other words, even if there were new misconceptions detected by this study, they need to be checked whether they were formed because of the related study or not or whether it was a chance for this study to detect the related misconceptions.

5.1.4 Discussion Related to the Results from the CMQ

In the study, results for pre-CMQ constructs were checked in terms of group and school independent variables separately to determine whether there was a significant mean difference between students for each construct by applying descriptive statistics analysis and inferential statistics analysis (MANCOVA and follow-up ANCOVAs).

When the descriptive statistics for pre-CMQ constructs were compared in terms of group independent variable (see Table 4.5), even if there was a small difference in the favor of control group for the pre- ANX mean scores and in the favor of experimental group for pre-SE, pre-GO, pre-IM and pre-SD constructs of pre-CMQ mean scores before the implementation, they were accepted as almost the same for the both groups. When the school independent variable was checked, the mean scores of students' pre-SE, pre-ANX, pre-GO and pre-IM were found to be a bit higher in the favor of science high school except pre-SD mean scores. Since these differences were also very small, they were also accepted as almost the same for the both schools before the implementation (see Table 4.7).

When the descriptive statistics for post-CMQ constructs were compared in terms of group independent variable, according to descriptive statistics, it was seen that the experimental group students scored significantly higher than the control group students in terms of each construct of motivation to learn chemistry (see table 4.5). That could be accepted as an evidence for CBL instruction to be more effective on students' motivation when compared to traditionally designed instruction in terms of students' motivation to learn chemistry.

When the descriptive statistics for post-CMQ constructs were analyzed in terms of school independent variable (Table 4.7), post-SE, post-GO, post-IM and post-SD scores were found to be higher for the science high school whereas for post-ANX, Anatolian high school students' scores were found to be higher. In other words, students in science high school improved their self-confidence (because of self-efficacy), success in grades (because of goal-orientation), interest (because of intrinsic motivation), degree of having fun (because of intrinsic motivation) and feeling control over their own learning process (because of self-determination) whereas Anatolian high school students lowered their anxiety level more when compared to science high school students.

What was remarkable here was, even if pre-SD scores were found to be in the favor of Anatolian high school and pre-ANX scores were found to be in the favor of science high school before the implementation, they changed in the reverse directions after the implementation. It was important to observe a shift to the opposite school in terms of the mean scores of post-ANX in the favor of Anatolian high school and another shift to the opposite school in terms of the mean scores of post-SD in the favor of science high school. The reason of this result might be because of Anatolian high school students feeling more completed after learning a difficult topic of chemistry, acids and bases which lowered their anxiety and science high school students finding a chance to control their own learning process as they also learned a difficult topic of chemistry. In other words, this difference might be formed regardless of the implementation effect. Another reason for this remarkable change might be because of the implementation. To be more specific, by the help of CBL instruction, students in Anatolian high school felt less fear for not understanding a concept related to acids and bases since they were the ones who were actively involved in their own learning process. Similarly, for science high school students, by the help of CBL instruction, students found a chance to control their own learning process so that they became aware of the concepts of acids and bases that they felt incomplete and they tried to overcome their deficiencies as much as possible which lead them to improved self-determination.

When the gain scores were analyzed for the CMQ constructs in terms of group independent variable (see Table 4.6), control group students seemed to gain higher scores than experimental group students in terms of self-efficacy (SE) construct of motivation. And for anxiety, goal-orientation, intrinsic motivation and self-determination, experimental group gained higher scores. The reason of students' self-efficacy scores to be improved more in the control group students might be because of their learning a difficult topic of chemistry, acids and bases since they had no idea of their misconceptions and if they learned the concepts related to acids and bases or if they memorized them. However, their confidence level (because of higher self-efficacy score) was improved more than experimental group students. In addition to this, a remarkable result was also revealed in terms of students' self-determination construct since the control group students' self-determination was lowered after the implementation. This might be caused because of the traditionally designed instruction since it was not allowing students to judge their own learning or control it.

When the gain scores were analyzed for the CMQ constructs in terms of school independent variable (see Table 4.8), it was found that the students in Anatolian high school gained higher scores than science high school students in terms of self-efficacy, anxiety, goal-orientation and intrinsic motivation constructs of motivation. This result was not very surprising since the students in the science high school have special interest in science as it could be understood from its name. They enter this school by winning an entrance exam as the Anatolian High school students with one difference: the students in science high school were generally the ones who really have so much interest in science when compared to Anatolian high school students. Thus, they might be accepted as more motivated to learn chemistry. So; there was a smaller increase between pre and post CMQ scores for science high school students than the Anatolian high school students. However, in terms of self-determination, the gain scores for the students in the science high school were higher than the students in the Anatolian high school. This result may be because of science high school students being already aware of their interest or talent in science more than the Anatolian high school students generally, so that they were more motivated to learn chemistry before the implementation when compared to Anatolian High school students. So, the other constructs of motivation in science high school students were already higher and since self-determination needs more effort to be improved, and since science high school students had lower scores in terms of self-determination construct before the implementation, they might be more focused on their self-determination with CBL instruction unwillingly which result in a higher gain score in terms of self-determination when compared to Anatolian high school students.

Also; even if there was not seen any statistically significant difference between the constructs of CMQ in terms of control group, there was a little increase after the implementation for each construct. This small increase may be because of students' feeling a relief after learning a difficult subject which makes it easier to solve related questions so that they became a bit motivated to learn what they afraid of next.

When the results of the CMQ were checked in terms of the total means scores of the CMQ for both groups (see Table 4.59), it could be seen that there was an increase in both of them while this increase was smaller for the control group. That is, 3.11 points of increase for control group and 15.34 points for experimental group. When the results of the CMQ were checked in terms of the total means scores of the CMQ for both schools (see Table 4.60), it was seen that there was again an increase in both of them whereas this time the increase for both school were very close to each other in the favor of science high school. The difference between the pre and post CMQ was 9.62 points for the Anatolian High school students and 8,91 for the science high school students. Even if the gain score for science high school was lower, the pre and post-CMQ scores were higher than the Anatolian high school students. This result may be because of science high school students be more motivated to learn chemistry than Anatolian high school students independent from the study so that, the gain score was lower.

After the descriptive analysis, MANCOVA analysis was conducted to explore the effect of treatment and different school types on constructs of motivation to learn chemistry (See Table 4.25). According to the obtained results, it was found that CBL instruction was affecting each construct of motivation whereas the school type does not affect any of the motivational constructs. In other words, CBL instruction was affecting students' motivation (by affecting the constructs) regardless of school type which was also a valuable finding for the related literature.

In addition to MANCOVA analysis, the follow-up ANCOVAs were conducted as a double check for the study and for gaining a deeper view for the results. According to these analysis results, the same findings were revealed as the MANCOVA analysis results.

At the beginning of the inferential analysis, students' pre-CMQ construct scores were analyzed in terms of descriptive statistics and it was found that even if there were small differences in the scores some of which were in the favor of experimental group and the others were in the favor of control group. However, according to inferential statistics, these differences for group independent variable were not found to be statistically significant. In other words, there was no statistically significant difference on the mean scores of the CMQ constructs for both groups; however after the implementation, the mean scores of the post-CMQ constructs of the experimental group was higher than the ones in the control group. In addition to that, according to inferential statistics, the results of this study indicated that CBL instruction did not improve students' motivational constructs for both schools since the differences between pre and post tests were not found to be statistically significant.

Even if there were differences between both schools in terms of motivational constructs they were not statistically significant. Thus, the reasons that may cause this result were tried to be detected. One of the reasons of this could be because of the time the implementation took. In other words, improving students' motivation needs some time, however the CBL implementation took only 12 weeks which may not be sufficient to change any of the motivational constructs that results in an increase in students' motivation. Another reason that may result in this may be because of the curriculum to be so crowded (Pintrinch & Schunk, 2002) that it may reduce the effectiveness of this study in terms of improving students' motivation.

Moreover, even if this difference was not statistically significant, there was a small difference found between both schools. When the reasons of this difference was explored, According to Pintrich and Schunk (2002), the reasons that cause such a difference between two schools (Anatolian & Science) were student type, self-efficacy or the size of the school for students' motivation to change. In this study, even if both cities show similar properties in many ways, science high school students were instructed in a smaller city of Turkey in which education and success were very important according to its culture and since the city was not very large, the students might find a chance to interact with each other more inside and outside of the school. In addition to that, since science high school students were more interested in science, it may also increase the interaction between student-student and teacher-student (Eccles et al., 1993), which was crucial for effective CBL instruction.

In both schools, case studies were performed in the same manner. However, students' scores in terms of each construct were changing. First of all, the students in science high school scored higher than students in Anatolian high school in terms of self-efficacy construct of motivation. Self-efficacy was described as one's being confident in terms of his/her achievement to be well in science (see Lawson, Banks, & Logvin, 2007). In other words, science high school students' self-efficacy for learning increased after the implementation; which means students' confidence in terms of their skills essential to carry out the lectures of chemistry increased more than Anatolian high school students. According to Pintrich and Schunk (2002), model using during lectures increases self-efficacy and so students' motivation to work on a given task on their own. In this study, even if the students worked in groups, they all read the cases by themselves, tried to answer the questions by themselves and then turn to their group mates and discuss as much as possible. According to the results of the study, science high school students' felt more confident to themselves while they were working on their own since they scored higher than the Anatolian high school students.

Second of all, anxiety, that is a sign of worry and concern, is an important factor that affects students' learning, understanding and achievement. It could be assumed that each student' anxiety was increased from time to time and according to Cassady and Johnson (2002) it was expected from the students to have a moderate level of anxiety for increasing motivation of the students. The findings of this study revealed that, students' that are in Anatolian High school get higher anxiety scores than the science high school students in the post-CMQ. One of the reasons for this result may be because of these students' anxiety was increased due to lack of time since they were given only one class hour to fill post-CMQ next to post-ABT that might make science high school students become worried than Anatolian high school students. Another reason for this result may be because the students knew that their scores of each test would be compared with each other at the end of this study. Thus, even if the student' were told that their names would not be used after the study for ethical reasons, science high schools students might become more anxious than the Anatolian high school students. Also, one other reason might be because of students' not being familiar with the CMQ test. Since science high school of this study was in a smaller city than Ankara, there were not many tests applied to these students during their education years. However, since the Anatolian high school enrolled in this study was in Ankara and there were many universities that were making studies, some other researchers maybe applied a similar test on the Anatolian high school students so that they were familiar to these kinds of tests. Actually the literature was supporting this idea: according to Hill and Wigfield (1984) if students were unfamiliar to the tests, this might cause anxiety in students. Lastly, another reason for Anatolian high school students to have higher anxiety scores after the implementation might be because of their fears from the university entrance exam to be lowered than science high school students as the time passes. In other words, independent from the study, the students in the science high school may have more expectations from the university entrance exam when compared to Anatolian high school students which was very important in Turkey and these expectations brought high anxiety to science high school students' life as the time passes and the time for the exam is approaching. Thus, they became worried about their success more when compared to Anatolian high school students. This may result the students in the Anatolian high school to have higher anxiety scores accordingly. Another reason for this result may be because of Anatolian high school students being more self-confident. In other words, again independent from the study, may be the students in the Anatolian high school trust their knowledge and themselves more since their teachers' or families' ability to teach and motivate them is higher.

Third of all, science school students' goal-orientation scores also increased after the implementation more when compared to Anatolian high school students. Goal orientation refers to why and how students engage in academic activities (Vedder-Weiss & Fortus, 2010). Thus, for making a comment on this construct, it would be better to think about the reasons of students will to be involved in this implementation. The reason might be science high school students' giving more importance to specific goals such as getting rewards, bonuses, grades (Çetin-Dindar, 2010) when compared to Anatolian high school students that would affect their school performance which was crucial for their university entrance exam. Another reason might be because students enjoying their teachers' teaching (Ramnarain, 2013).

Fourth of all, as it could be seen from the descriptive statistics for post-CMQ constructs science high school students' intrinsic motivation scores also increased after the implementation more when compared to Anatolian high school students. It was not surprising since these students show more interest to science that they win an exam to be a part of science high school. In other words, in science high schools, the students had more lectures related to science courses and the students enjoyed it. For this reason, it can be concluded that students of science high school found CBL instruction to be more interesting and enjoyable when compared to Anatolian high school students since their intrinsic motivation scores were higher than the Anatolian high school students and even if Anatolian high school students' intrinsic motivation was also increased after the implementation, it was inevitable for science high school students to have more fun and show more interest to the study when compared to

Anatolian high school students. According to literature there were findings that studied on CBL instruction and the students were found to find this instruction interesting and fun (see Brickman et al., 2008; Heid et al., 2008; Parilla, 2007; Ribbens, 2006). According to Pintrich and Schunk (2002) intrinsic interest or enjoyment are some of the reasons of students become willing to learn science so that their motivation was increasing.

Lastly, the students in the science high school gained higher scores than the Anatolian high school students in terms of self- determination in the post-CMQ test. One of the reasons of this result may be because of science high school students needed more space before the implementation to decide on the activities they would like to work on but it was not the case. During the implementation, they might felt more free to choose, decide and control their learning so that, their self-determination scores were increased after the implementation even if this increase was not statistically significant. Another reason for science high school students to have higher self-determination scores after the implementation may be because of their beginning to examine own selves and find their deficiencies that needed to be remedied as the time passes. In other words, independent from the study, science high school students may be giving more importance to their deficiencies in terms of the courses they take and they feel a need to complete them more when compared to Anatolian high school students.

Moreover, as mentioned above, when the descriptive statistics were analyzed in terms of group independent variable, it was found that there was a negative score change in the self-determination construct of motivation for the control group. In other words, the students' self-determination was decreased after the implementation for the control group students that was also found to be a remarkable point to talk about. One of the reasons of this may be because of the traditionally designed instruction making students lose their attention and motivation because of being inactive and not finding a chance to ask question during the lectures so that their determination of which concepts they did not understand or they are weak, how they need to study to overcome their misunderstandings etc. According to Reeve, Hamm and Nix (2003), self-determination is described as being able to make choices and some degree of control on what to do and how to do that. For Glynn and Koballa (2006), when the students were lack of self-determination, they would believe that they could not control the course so that they did not want to spend much effort on their learning process. In this study, by letting students feel free while they were studying on cases and while they were answering the questions about cases it was also provided students to feel their control over the learning process of themselves.

There were many studies that emphasized on the effect of motivation in the learning process. To give an example, a study conducted by Black and Desi (2000) that studied on analyzing students' motivation on organic chemistry, mentioned that learning was influenced by students' being motivated to learn. In addition to this study, Pintrich et al. (1991) mentioned, the students' understanding of the concepts would be affected by being a part of some motivational activities. There were some other studies that found motivation as an influencing factor for learning (see Guvercin, Tekkaya, & Sungur, 2010; Pintrich, 2003; Pintrich & Schunk, 2002; Schunk, 1991). Accordingly, when the results of this study were analyzed, it was seen that even if some of the constructs related to CMQ were not statistically significant, they were all increased as mentioned above. Therefore, it could be accepted as an evidence that the students' motivation to learn chemistry was increased with the CBL instruction as the current study provides further empirical support for the study conducted by Pintrich and Schunk (2002), in which it was proposed for students to be more motivated to learn when they took an active part in activities and when they work in groups cooperatively (Meece & Jones, 1996).

In addition to these results, when the Table 4.24 was analyzed, it was seen that the students' the interaction between school and group was not significant. However, when Table 4.25 was analyzed for further information, it was found that there was a statistically significant interaction between school types and the groups the students were involved in terms of goal-orientaton and self-efficacy constructs of motivation. So, the students' self-efficacy and goal-orientation scores were affected in terms of their being in the experimental or control groups of Anatolian or science high schools. In other words, the effect of students' being in the control or experimental group for the self-efficacy and goal-orientation constructs of motivation is dependent on the school type the students were enrolled such that, for experimental group, Anatolian high school students scored higher than the science high school students in terms of both self-efficacy and goal-orientation constructs of motivation. However, for control group, the effect were opposite with science high school students scored higher than the Anatolian high school students in terms of both self-efficacy and goal-orientation constructs of motivation. Thus it can be concluded that CBL instruction effected students’ self-efficacy and goal-orientation more in the Anatolian high school than science high school. First of all it was not very suprising to see self-efficacy and goal-orinetation constructs showing the same effects since According to Bandura (1977) self-efficacy plays a major role in how goals were reached. So, the effects seen in self-efficacy construct of motivation show parallel effects in goal-orientation construct of motivation. The reason of this result may be because of the science high school students’ beliefs about their own self-efficacy and goal-orientation being resistant to change. In other words, science high school students might be thinking that they were already locked to their goals, they already knew their own capabilities, abilities and they already have an idea about what they want before the implementation and they did not change their beliefs because of lack of sufficient time pass for this change when compared to Anatolian high school students. Thus, even if the treatment was effective, the Anatolian high school students were affected more than the science high school students in terms of self-efficacy and goal-orientation constructs of motivation to learn chemistry. In other words, the students’ belief in their their abilities and capabilities were improved next to being more focused to the goals they decided to reach more than the science high school students because of science high school students’ beliefs being resistant to change. Another reason might be the teachers’ positive encouragements that help students to decide on the goals and achieve them more easily. In other words, since Bandura (1977) mentioned about the importance of social persuasion which might be provided by the teachers of this study; the teacher in the science high school might persuade their students less to believe that they had the abilities, skills and capabilities to succeed when compared to the teachers in Anatolian high school.

To conclude, in this study, students' total motivation was measured by summing the five constructs of the CMQ instrument used in this study. However, instead of including the total motivation score in the analysis, each construct of CMQ were included into the study separately since all constructs were related to the aims of this study. Thus, CBL instruction was found to be effective in terms of each construct of motivation regardless of school type when compared to traditionally designed instruction. This was an important finding since there were not any studies that explored the effect of CBL on students' motivation to learn chemistry in terms of different school types by studying on acids and bases concepts. Another finding according to this study results was, when the self-efficacy and goal-orientation constructs were analyzed including school types and group interaction; the Anatolian high school experimental group students were found to score higher than science high school experimental group students. This revealed science high school experimental group students to be more resistant to change their beliefs about their abilities and their goals when compared to Anatolian high school students. Moreover, when two types of schools were compared according to descriptive statistics by including the groups, the motivational constructs were all improved in the control and experimental groups of both schools whereas, these improvements were higher in the experimental groups of both schools (see Table 4.9 and Table 4.10) revealing another proof for CBL instruction being more effective in terms of improving students' motivation when compared to traditional instruction.

5.1.5 Discussion Related to Researcher's Notes

In this study, the experimental and control groups were observed by the researcher as much as possible in which the researcher took some notes related to each observed lecture. According to the literature, CBL was found to be effective for improving students' critical thinking (Alvarez, 1990; Bennett 2010; Uluyol & Güyer, 2014; Yoo & Park, 2014), social skills (Yalçınkaya, 2010), creativity (Garvey et al., 2000; Thistlethwaite et al., 2012) and their higher order thinking skills (Herried, 1994; Tarkın, 2014). As the results according to researchers' notes were analyzed, it was found that the students in the experimental groups improved their understanding and became more motivated to learn acids and bases concepts since they had more fun while learning the acids and bases concepts, felt more free to express their feelings and ask their questions, actively involved in discussion environment, an studied in groups that improved their self-confidence next to their social skills. Furthermore, there were some questions in some of the cases that activated students' curiosity and make them feel the need to make researches to find the related questions' answers. Thus, the students were sharing their ideas in their groups and with all class for defending their opinions after their searches for these questions. According to the researcher's notes, the cases in this study also lead students to make analizations, think logically, use their imagination and make inferences accordingly so that students' creativity, critical thinking and higher order thinking skills next to their attention were improved since one of the aims of the designed cases was making these positive effects on students as the literature supported. Thus, the cases should be designed by considering these positive effects of CBL instruction on students and an instrument should also be included to the study to evaluate these effects statistically.

Moreover, the cases designed for this study prepared by taking interdisciplinary teaching and Nature of Science (NOS) aspects into account According to the literature, it was crucial to integrate NOS into science teaching and curriculum (Lederman, Lederman & Antink, 2013) and apply interdisciplinary teaching (Sumter & Owens, 2011) to improve students' understanding of the world, prepare students to life and grow scientifically literate people (Partin, Underwood & Worch, 2013). The researcher's notes also showed that, the students became more interested and be more motivated during cases that involved interdisciplinary teaching and an aspect of NOS embedded in them. The reason of this action of students might be because of students' realization of the holistic structure of science and their misconceptions related to the science which were not mentioned anywhere before. Thus, it would be better to involve NOS and interdisciplinary teaching as much as possible during teaching to make students scientifically literate as the Turkish curriculum aims.

Furthermore, since some acids and bases concepts were difficult for students to learn because of their abstract nature or because of different definitions of acids and bases. Also for some acids and bases concepts, it might difficult for students to make a connection between their prior knowledge and the new information (Çetingül & Geban, 2011; Yalçınkaya et al., 2012). In order to ease students' understanding of the related concepts and make the new information intelligible to students by comparing it with their prior knowledge, analogies were applied in two cases. In the first case, the reason of applying analogy was for making students' remember their previous knowledge related to acids and bases concepts more easily and in the third case, it was for remedying students' learning difficulties about the definition of acids and bases by different theories. There were many studies that were supporting the positive effects of analogies in learning complex scientific concepts (e.g. Calik et al. 2009; Orgill & Bodner 2004; Savinainen et al., 2005) and according to researcher's notes, for the first case, the students easily remembered the properties of acids and bases and for the third case, they had less difficulty in learning the acids and bases definitions acording to different theories. Thus, it can be accepted as a good solution to get help from analogies while designing cases when an abstract, complex or difficult concept was tried to be taught to the students. However, it would be better to conduct follow up interviews might be developed in order to gather students' opinions about involving analogies into cases next to the reflection papers.

5.1.6 Discussion Related to Reflection Papers

When the results of the reflection papers were analyzed, it was revealed that application of the reflection papers during this study had some important contributions to the study. First of all, by the help of reflection papers, the researcher get feedback about the implementation process, about students' understanding, about the cases strong and weak parts and about the teachers of the study and their success in teaching from students' point of view. Secandly, since the students found a chance to make critics about the cases, their critical thinking skills were also improved. Thirdly, the students also be involved in the process of evaluating their own learning, understanding, their degree of knowledge about the related acids and bases concepts and realize their misconceptions which helped them to improve their self-evaluation.

Moreover, as the reflection papers were analyzed on behalf of the study, reflection papers helped to gather some more information about the students' ideas of the whole study next to researcher's notes and the instruments used. The cases were criticized by the students of the study and the students' levels of understanding of the related concepts were mentioned through students' own eyes. In other words, the researcher collected feedback related to the study by the reflection papers.

According to the results of the reflection papers, students' taught that the cases were mainly helped them to understand acids and bases concepts, they became aware of their own misconceptions related to acids and bases concepts that lead them to overcome those misconceptions and the cases were mainly well-prepared however there might be some reforms applied for making the cases better for future usage.

According to the literature, students began to perform better on the given tasks when they think about what they understand from the task they completed before (Stefano et al., 2014) or reflecting on an action is crucial for improving students' learning (Schön, 1983). Thus, in this study, the reflection papers were applied to collect students' opinions about their own understanding and about the cases. In addition to these, by the help of reflection papers, feedbacks about the effectiveness of the CBL implementation as a whole was gathered from the students which were also used as an alternative to conducting follow-up interviews after the study that could not be conducted because of time restrictions.

5.1.7 Discussing the Results as a Whole

When the results of the study were analyzed, it was revealed that CBL was effective than traditionally designed instruction in terms of students' understanding of acids and bases concepts and their motivation to learn chemistry. These results were supported with the related literature for chemistry discipline (see Çam & Geban, 2013; Rybarczyk et al., 2007; Saral, 2008; Sendur, 2011, etc.). These positive effects of CBL in students' understanding and their being motivated to learn chemistry were related to the implementation style applied in this study. To give an example, in this study cases that include real-life situations which attract students' attention were used. In addition to that, the related cases included some of the nature of science aspects and some of them developed considering the interdisciplinary teaching that also improved students' interest to the study. According to literature, nature of science aspects were important to be integrated into teaching (Gencer, 2014) since one of the aim of teaching in high schools was growing scientifically literate youths for the future (Köksal & Şahin, 2014). In addition to that, since interdisciplinary teaching believed to facilitate comprehensive understanding (Newell 2007), by embedding interdisciplinary teaching into some cases, it was aimed to help students to relate what they learned in different disciplines of science that could help them to deal with the real world's complex issues (Spelt et al., 2009) and realize the holistic structure of science which means, science cannot be separated.

In addition to these, since the cases also formed by considering the real-life situations in which students work actively on, they apply their prior knowledge as much as possible next to their creativity, critical thinking and higher order thinking skills for solving the related events given in cases. Thus, it was not very surprising for CBL instruction to be effective for students' understanding of acids and bases concepts since they had a chance to apply their own abilities, skills and prior knowledge to understand and decode the background information given in the cases. Moreover, it was also not very shocking to find out students' motivation to be improved since students were actively working on each case in groups and be involved in discussions that take their attention and improve their self-confidence, social skills and consequently their motivation.

In this study, there were some differences between students that were observed but not statistically significant in terms of school independent variable. According to Fitz-Gibbon (1985), there may be small but significant differences on the performance of students who attend different types of schools and its reason because of the students being selected to be involved in science high schools when compared to Anatolian high school students. According to them, since a selective environment has the ability to stimulate an increase in students' understanding because of its potential to creates a beneficial competition and co-operation between students. In this study, the students in both schools were selected according to the same exam. In addition to that, one of the schools was in Ankara and the other one was in Karabük and the students mainly get close points from this exam even if generally science high school students were more successful than the Anatolian high school students. Because, the Anatolian high school was in Ankara and there were science high schools in Ankara that get the students with higher points. However, in Karabük, the most successful students were entering the science high school that can be accepted to get close scores to the Anatolian high school selected from Ankara according to their entrance scores comparisons. Even if this was the case, since the students were in science high school in Karabük, this situation creates a more selective environment in students' minds when compared to Anatolian High school students. Thus, the implementation of the study may result in more cooperation and competition between students while they were studying in groups which may increase their motivation towards chemistry and improve their understanding of acids and bases concepts.

At the beginning of the study, large effect size was set for this study. As the collected data of the study were analyzed, a large effect size was also found as the observed effect size (see Table 4.24) for the group independent variable. This finding indicates the present study to have both practical and statistical significance in terms of students' understanding and their motivation to learn chemistry. In addition to these, the observed power was found as 1.000 for the post-ABT and motivation questionnaire, which were both higher than the calculated power.

For the current study, it was important to mention about the limitations. First of all, even if the students in the experimental group filled reflection papers based on what they have studied about acids and bases at the end of each cases, these reflection papers were not filled by the control group students. It would be better for control group students to also fill the reflection papers after reaching the specific objectives of the study, so that at the end, both groups' answers should be compared. This is a limitation of this current study. In addition to that, in order to make both teachers and students familiar with CBL instruction, to overcome the Hawthorne effect and attitude threat to the study and to change the teachers' beliefs about new teaching methods, the CBL instruction began earlier than the implementation with a case about the chemical equilibrium unit and implemented on both control and experimental groups as mentioned above. It worked for overcoming the attitude of students threat and making the teachers and students familiar with the case a little, however, one case was not enough to change the beliefs of the teachers about traditional teaching and it was not enough to overcome the Hawthorne effect threat to internal validity with only one case. So, it would be better if the CBL instruction covered all chemical equilibrium units and applied to both groups which were also a limitation for this study. In addition to these limitations, there were four teachers in this study. Even if the teachers were accepted to be very similar to each other and the implementer effect tried to be remedied by training all the teachers, making them obey the lesson plans; their teaching might differ up to some point or they might apply some parts of the lesson plans used in the experimental groups to the control groups when there were not any observers in the lecture unconsciously or on purpose which may cause a limitation for the study even if they were tried to be prevented by joining as much lectures as possible in both schools and all of these lectures were followed by observation checklists next to researchers' notes. There was also another limitation that, the students in the experimental groups studied on more daily-life context as a part of the study when compared to the control group students. But after the implementation, all cases, pre and post tests were then brought together as a booklet and they were distributed to both groups of students.

Results of the studies like CBL would be negatively affected because of several external forces like students taking some private courses, going to "dershane", etc. In this study, the pre-test scores of students in both schools and groups were higher than it was expected in reality and they were because of these foundations in which the concepts of acids and bases were already mentioned. Luckily, this year, Turkey decided to close the private foundations like "dershane" or "etüt merkezi" which was important since turning to student-centered teaching strategies in schools that were aiming to actually teach students and improve meaningful learning were affected by these foundations since they were mainly focused to improve students' test solving speed or improve their memorizing ability only and never gave importance to what students really learn in reality that results in meaningful learning because of the university entrance exam. However, closing this type of foundations was not the real solution. The university entrance exam needed to be changed or abolished by the laws so that a students' future was not depend on some exams. By this way, students should not need to focus on increasing their speed for solving the questions in a test to win an exam, and they should be focused on learning new concepts meaningfully and take their time during the learning process which lead them to understand the reason of learning the related concepts or the importance of being scientifically literate people.

Another external force that lowers the effectiveness of the CBL instruction was the crowd in the curriculum. With a crowded curriculum, teachers could not find time to teach the related concepts deeply and efficiently. Instead, they aimed to mention each concept superficially to catch up the curriculum. When this was the case, even if some teachers wanted to apply student-centered teaching methods to improve students' understanding, they could not help but apply a teacher-centered, traditionally designed instruction method. Also, because of the same reason, students could not learn a new concept deeply and they also could not find time to ask the questions on their minds since the time was restricted because of this crowded curriculum. In this study, this crowd in the curriculum was also a problem during the formation of the cases. Because, since the teachers mentioned many concepts related to acids and bases superficially, students' misconceptions were needed to be taken into account as much as possible next to covering all the related concepts in the curriculum for better learning which was a tiresome and difficult process. For this purpose, the education system in Turkey was tried to be restructured and first, a year was added to the high school which was a positive thing for meaningful learning. Then, the curriculums of each grade of high school were begun to be reformed. However, by these reforms, the curriculum was restructured with additional information so that it began to be crowded once again and there were not any time left for student-centered teaching methods to be applied at all which brings the same problem into the stage once again. For this reason, the Turkish curriculum in chemistry needed to be reformed with extracting the unnecessary information out of it and leave time to apply new, constructivist teaching strategies that also involve technology into account during teaching.

Another external problem that could be faced with during the application of new teaching methods could be teachers' and students' lack of familiarity with them, for this study CBL. Especially for the experienced and older teachers, there was a belief that traditional teaching was enough and best for teaching and learning. Thus, they did not want to break their old habits of teaching traditionally to follow a new teaching method that causes problem for its implementation in classes. According to Kane, Sandretto and Heath (2002) and Pajares (1992) the beliefs were resistant to change. However, it was crucial for teachers to manage the classroom discussions or for students to be familiar with the group work activities during CBL instruction so that it could be applied correctly and effectively. According to Gallucci (2007), for applying case-method effectively, teachers' enthusiasm is an important factor. In this study, in order to erase this belief from teachers' minds, and make the students and teachers familiar with the CBL instruction, an example of lecture was applied on one of the chemical equilibrium concepts that were before the implementation as an example to the teachers and students. Then, results of similar studies were brought to the teacher to show the success of the method. In addition to these, the researcher tried to observe as much lectures as possible for preventing the teachers' beliefs to be mixed into their teaching. Actually, it would be better if the CBL instruction should be applied to whole chemical equilibrium unit that would also lower the attitude threat to the study for the same aims but it could not be carried out because of the time restrictions.

A disadvantage of CBL that might come to the stage was its being over contextualization (Yalçınkaya, 2010). Since generally one case or scenario was applied to teach a concept, there may be students that could not understand the related concept with only one case. Thus, when necessary, multiple cases could be designed for the concepts that were found to be more difficult for students understanding according to the literature even if it would be time-consuming or complex cases could be designed that covers more concepts (Gallucci, 2007).

To sum up, although there were some limitations and situations that lowered the effectiveness of CBL in this study, at the end, according to the results of this study, it could be concluded CBL to be an effective teaching strategy in terms of improving students' understanding and motivation to learn chemistry and overcoming students' misconceptions since it was a student-centered teaching instruction in which students are actively engaged during the learning process that promote meaningful learning and understanding; or overcome students misconceptions. However, its application takes time and effort especially for the teachers because of their acting as a facilitator when compared to the traditionally designed instruction. Moreover, CBL is also said to improve students 'creativity, critical thinking skills, social thinking skills and higher order thinking skills although there were not any instruments used to measure the change in these abilities of students in this study. For this reason, it is advised to apply CBL instruction to support meaningful learning, deeper understanding, improving the related abilities and overcoming misconceptions of students when there were efficient time for students to learn new concepts of any discipline in science with some more instruments to measure students' related abilities and when CBL is appropriate to be applied.

5.2 Generalization (External Validity)

In this study, there were 292 students participated so that the effect of case based learning (CBL) was compared in terms of students' understanding of acids and bases concepts and their motivation to learn chemistry with traditionally designed instruction. At the end of the study, the findings indicated that there were significant differences on overall the effect of teaching methods in favor of case based learning (CBL) instruction when CBL and traditionally designed instruction on the population mean of the collective dependent variables of eleventh grade students' post-test scores of acids and bases unit of chemistry and motivation constructs to learn chemistry were taken into account. Since the number of the students in the study (n=292) exceeds the 10% of the accessible population, these findings of the study could be generalized to the accessible population.

5.3 Implications of the Study

According to the results of the study, it could be concluded that the findings related to this study have clear implications for chemistry teaching and learning for the practical applications. The suggestions for the implications of the present study are as follows:

- For improving students' understanding of the acids and bases concepts, constructivist teaching strategies (such as case based learning) should be used.
- For improving students' self-efficacy, anxiety, goal-orientation, intrinsic motivation and self-determination which are the constructs of motivation to learn chemistry, constructivist teaching strategies (such as case based learning) should be used.
- Cases that were designed as student-centered activities should be used to increase students' motivation to learn chemistry.
- Prior knowledge of the students should be taken into account before teaching a new unit in chemistry.
- Students should have some misconceptions in acids and bases unit of chemistry. Teachers should use teaching strategies that reveal these misconceptions and try to overcome them.
- Teachers may also have misconceptions that should pass to the students and narrow down the students' view. Thus, teachers should be given importance to their own development which could be a must in case based learning.
- In order to take students' attention, increase their motivation (by increasing the constructs of motivation) and for meaningful learning to occur, it was crucial to apply daily-life problems and real life context should be applied during teaching acids and bases concepts.
- Nature of science should be included when applicable for students to overcome misconceptions related to science as a whole and to increase students' scientific literacy.

- Interdisciplinary teaching should be included into teaching when applicable so that students should understand the integrity of science and how to link different parts of science to each other.
- Discussion environment during learning and teaching progress is important for increasing students' understanding and motivation to learn chemistry so that teachers should give importance to create discussion environment
- Students should learn from each other too. For this reason supporting group work is crucial. Teachers should form groups during teaching for better understanding as it occurs in case based learning.
- For motivation to learn chemistry to increase, teacher-student interaction is a key point. For this reason, teachers should be more emphatic with their students and take students' feelings, values, experiences, and their needs into consideration as much as possible during planning their lectures.

5.4 Recommendations for Further Researches

According to the findings from this study, the following recommendations could be stated:

- The effect of case based learning instruction could also be tested with different chemistry topics.
- New constructivist teaching strategies should be developed and the effect of these new constructivist teaching strategies could also be tested on acids and bases topic.
- Before beginning to the instruction, instead of implementing only one case related to the prior unit, cases related to whole prior unit should also be prepared and applied in order to eliminate the novelty effect.
- More school types and environmental conditions should be included and it would be better to increase the sample size and the number of cities studied for improving the external validity of the study. In other words, for making it easier to make generalizations to a higher group of people, the test should be applied on a broader range of schools, cities and sample.

- It would be better if the test that measures only students' achievement about acids and bases concepts was also developed and applied. So that the effect of CBL instruction on students' achievement should be analyzed directly, separately and more deeply.
- In order to test the durability of the acids and bases concepts, a retention test should be distributed to the students since no retention test was used in the present study because of the lack of time.
- For better analysis, follow up interviews should be conducted with the students.
- A longitudinal study should be conducted in order to observe the effect of case based learning instruction on each construct of motivation to learn.
- More cases should be designed for the study to mention all concepts deeply and remedy more misconceptions in the acid base chapter.
- The revealed misconceptions with this study should be analyzed with a different sample to check whether they occur in different samples and conditions and remedied with different teaching methods.
- Factorial analysis was conducted on the science motivation questionnaire to see if the same constructs would yield correctly for this study too.
- Teacher should still have misconceptions. So; a test should be developed to apply on teachers to detect if they hold misconceptions or some in-service training could be prepared that aimed to overcome teachers' misconceptions about each chemistry topics by the researchers.
- Analysis of teacher motivation for teaching and its constructs should also be taken into account while teaching by case based learning instruction.
- Some studies conducted on case based learning had some evidences about its effect on developing students' creativity, higher order and critical thinking skills next to their social skills. Some instruments for measuring the change in these abilities should be designed and/or applied in addition to these study materials.
- Nature of science (NOS) was an important issue to be integrated into teaching. Even if there were some cases that integrated nature of science in this study, not all of the aspects were introduced to the students. Thus, all aspects of nature of

science should be taught to students integrated into cases and an instrument should be designed to evaluate students' understanding of NOS aspect should be included in the future studies.

- Interdisciplinary teaching was also another aspect to be applied during teaching. In this study interdisciplinary teaching were integrated into cases as much as possible. However, there might be more cases that should relate different disciplines with each other in the future studies.

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APPENDIX A

MEB PERMISSON (MEB İZNİ)

EFD BA

T.C.
MİLLÎ EĞİTİM BAKANLIĞI
Ortaöğretim Genel Müdürlüğü

Sayı : 84037561/605.99/1404691 04/04/2014
Konu : Araştırma İzni

ORTA DOĞU TEKNİK ÜNİVERSİTESİ REKTÖRLÜĞÜNE

İlgi : Ankara Valiliğinin 31/03/2014 tarihli ve 14588481/605.99/1323306 sayılı yazısı.

Üniversiteniz Ortaöğretim Fen ve Matematik Alanları Eğitim Ana Bilim Dalı Doktora Programı öğrencisi Demet YILDIRAN'ın "Olaya Dayalı Öğrenmenin 11. Sınıflarda Okuyan Öğrencilerin Kimya-Asit Baz Konusundaki Başarı ve Motivasyonlarına Etkisi" başlıklı araştırma çalışmasına dair ilgi yazı ve eki incelenmiştir.

Üniversitenizce kabul edilerek onaylı bir örneği Bakanlığımızda muhafaza edilen 27 sayfa 64 sorudan oluşan veri toplama araçlarının eğitim ve öğretim aksatılmadan, gönüllülük esas olmak üzere ders saatleri dışında Genel Müdürlüğümüze bağlı okulların 11. sınıflarında öğrenim gören öğrencilere yönelik olarak uygulanmasında bir sakınca görülmemiş olup gerekli duyurunun Üniversiteniz tarafından yapılıp araştırma tamamlandıktan sonra araştırma dokümanlarının bir örneğinin Bakanlığımıza gönderilmesi hususunda

Bilgilerinizi ve gereğini rica ederim.

Ercan TÜRK
Bakan a.
Genel Müdür

Güvenli Elektronik İmzalı
Aslı İle Aynıdır.
07 Nisan 2014

Fevzi PARLAK
VHKİ

Bu belge, 5070 sayılı Elektronik İmza Kanununun 5 inci maddesi gereğince güvenli elektronik imza ile imzalanmıştır
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Ayrıntılı bilgi için: Muammer AKSOY Eğitim Uzmanı
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APPENDIX B

ETHICAL APPROVAL (ETİK ONAYI)

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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06.03.2014

Gönderilen : Prof. Dr. Ömer Geban
Ortaöğretim Fen ve Matematik Alanları Eğitimi

Gönderen : Prof. Dr. Canan Özgen
IAK Başkanı

İlgi : Etik Onayı

Danışmanlığını yapmış olduğunuz Ortaöğretim Fen ve Matematik Alanları Eğitimi Bölümü öğrencisi Demet Yıldıran'ın "Olaya Dayalı Öğrenmenin 11. Sınıflarda Okuyan Öğrencilerin Kimya Asit-Baz Konusundaki Başarı ve Motivasyonlarına Etkisi" isimli araştırması "İnsan Araştırmaları Komitesi" tarafından uygun görülerek gerekli onay verilmiştir.

Bilgilerinize saygılarımla sunarım.

Etik Komite Onayı

Uygundur

06/03/2014

Prof.Dr. Canan Özgen
Uygulamalı Etik Araştırma Merkezi
(UEAM) Başkanı
ODTÜ 06531 ANKARA

APPENDIX C

ACIDS AND BASES TEST

ASİTLER VE BAZLAR TESTİ

Sevgili öğrenciler, aşağıda sizler için hazırlanan soruları lütfen dikkatlice okuyunuz. Size en uygun gelen cevabı yuvarlak içine alınız. Eğer sorunun cevabını bilmiyorsanız; lütfen "Bilmiyorum" seçeneğini işaretleyiniz.

1. Asit ve bazlarla ilgili olarak aşağıdakilerden hangisi ya da hangileri **doğrudur?**

I. Bazların tatları genelde acıdır.

II. Asitler kırmızı turnusol kâğıdını maviye çevirirler.

III. Bazlar mavi turnusol kâğıdını kırmızıya çevirirler.

IV. Asitler ve bazların suda çözünmesiyle oluşan çözeltiler elektriği iletirler.

A) I ve III

B) I, II ve III

C) I,II ve IV

D) I ve IV

E) Hepsi

O Bilmiyorum

2. Asitlerle ilgili olarak, aşağıdaki ifadelerden hangisi **yanlıştır?**

A) Asitler, proton verebilen maddelerdir.

B) Zayıf bir asidi suya eklediğimizde hidronyum (H_3O^+) iyon derişimindeki artış çok değildir.

C) Asitlerin asitlik kuvvetleri, formüllerindeki hidrojen sayısı ile doğru orantılıdır.

D) Zayıf asitler, elektrik akımını az da olsa iletirler.

E) Derişimleri aynı olan farklı asitlerin kuvvetleri aynı değildir.

O Bilmiyorum

3. Asit ve bazlarla ilgili olarak; aşağıdakilerden hangisi ya da hangileri **yanlıştır?**

I. Bir maddenin bazik olabilmesi için yapısında kesinlikle OH^- bulunmalıdır

II. Tüm asitler ve bazlar zararlı ve zehirlidir.

III. Asit ve bazlar içlerine atılan metalleri eritip yok ederler.

IV. Asit ve bazlar sadece derişimleri eşit ise birbirleriyle nötrleşme reaksiyonu verir.

A) Yalnız II
B) I,II ve III
C) I ve IV
D) I, III, IV
E) Hepsi

O Bilmiyorum

4. 400 ml 0,5 M $Ca(OH)_2$ çözeltisini tam nötrleştirmek için 500 ml HCl çözeltisi harcandığına göre, HCl çözeltisinin derişimi kaç molardır?

A) 0,8 **B)** 0,6 **C)** 0,5 **D)** 0,4 **E)** 0,2

O Bilmiyorum

5. 2 gr NaOH kuvvetli bazının 500ml çözeltisi için;

I. $[OH^-]= 10^{-1}$ M'dır.

II. pH= 13'dür

III. Baziktir.

yargılarından hangileri **doğrudur?** (NaOH = 40 gr/mol)

A) Yalnız III **B)** I ve II **C)** Yalnız II **D)** I ve II **E)** I,II ve III

O Bilmiyorum

6. Asit ve bazlarla ilgili olarak; aşağıdakilerden hangisi **doğrudur?**

A) Zayıf bir asitin sulu çözeltisinde OH^- iyonu bulunmaz.

B) H^+ içeren tüm çözeltiler asittir.

C) Kuvvetli asit daima konsantre asittir.

D) Bir asit-baz titrasyonunda indikatör kullanılmasa da nötralleşme reaksiyonu gerçekleşebilir

E) Kuvvetli bir asit ile kuvvetli bir bazın nötralleşmesi sonucu oluşan tüm çözeltilerin pH'ı 7'dir.

O Bilmiyorum

7. Aşağıdaki bilgilerden hangisi **doğrudur?**

A) Meyvelerin tatlarında asitliğin ve bazlığın bir etkisinden söz edilemez.

B) Asitler zararsızdır. Bu sebeple asit yağmurları tarihi eserlere zarar vermezler.

C) Yanma olayları sırasında, karbon (C) ve hidrojen gazı (H_2) su (H_2O) ile tepkimeye girerek asit formuna dönüşür.

D) Yediklerimizi sindirirken midemizde bulunan asitlerden yararlanırız.

E) Asit içeren maddelerin hiçbiri yenilemez ve içilemez.

O Bilmiyorum

8. Bir araştırma grubunun deniz suyunu analiz etmek için aldığı bir numune de $[H^+]$ iyon derişimi $1{,}0 \times 10^{-6}$ M olduğuna göre; deniz suyunun pH ve pOH değerleri aşağıdakilerden hangisinden **doğru** olarak verilmiştir?

	pH	**pOH**
A)	6	6
B)	6	8
C)	8	6
D)	8	8
E)	1	13

O Bilmiyorum

9. pH ve pOH için aşağıdakilerden hangisi ya da hangileri **<u>doğrudur?</u>**

I. pOH arttıkça bazın kuvveti artar.

II. Baz çözeltilerinde de H^+ bulunduğundan pH hesaplanabilir.

III. pH <u>sadece</u> asitliğin bir ölçüsüdür.

IV. pOH = 0 olan bir çözelti yapılabilir.

A) Yalnız III

B) II ve IV

C) I ve II

D) I,III ve IV

E) I, II ve IV

O Bilmiyorum

10. 25°C'de sulu çözeltilerin özellikleri ile ilgili olarak;

I. pH > pOH ise; $[H^+] > 1x10^{-7}$ M'dır.

II. $[H^+] > [OH^-]$ ise; pH > 7'dir.

III. pOH < 7 ise $[H^+] < 1x\ 10^{-7}$ M'dır.

yargılarından hangisi veya hangileri **<u>doğrudur?</u>**

A) Yalnız I

B) Yalnız II

C) Yalnız III

D) I ve II

E) I ve III

O Bilmiyorum

11. $$NH_4^+ \text{ (suda)} + H_2O \text{ (s)} \rightleftharpoons NH_3 \text{ (suda)} + H_3O^+ \text{ (suda)}$$

Yukarıda verilen asit-baz tepkimesinde **<u>bazik</u>** özellik gösteren maddeler hangileridir?

A) H_2O ile H_3O^+

B) NH_4^+ ile H_3O^+

C) NH_3 ile H_3O^+

D) H_2O ile NH_3

E) NH_4^+ ile H_2O

O Bilmiyorum

12. Bronsted-Lowry asit baz teorisine göre;

I. Asitler başka maddeye proton (H^+) veren maddelerdir.

II. Bazlar başka maddelerden proton alan maddelerdir.

III. NH_4^+ katyonu, proton verebilme özelliğine sahip olduğundan Bronsted-Lowry asididir.

yargılarından hangileri **doğrudur?**

A) Yalnız I

B) I ve II

C) II ve III

D) I ve III

E) I,II ve III

O Bilmiyorum

13. Suda asidik/bazik özellik gösteren katyon ve anyonlarla ilgili olarak;

I. Zayıf bazların konjuge asitlerini içeren tuzların çözeltileri asidik özellik gösterir.

II. Katyonlar kolayca proton alarak bazik özellik gösterirler.

III. Zayıf asitlerin konjuge bazlarını içeren tuzların çözeltilerinin $[H^+]$ derişimi yüksektir.

IV. Çapı küçük, yükü büyük olan metal katyonları sulu çözeltilerine H^+ iyonu vermeseler de çözeltileri asidiktir.

yargılarından hangisi ya da hangileri **doğrudur?**

A) I ve II

B) II ve III

C) III ve IV

D) I ve IV

E) I,II ve IV

O Bilmiyorum

14. Asit ve bazların yapılarındaki anyon ve katyonlarla ilgili,

I. Zayıf asitin konjuge bazı olan anyon zayıf baz özellik gösterir.

II. Kuvvetli bir asitin konjuge bazı olan anyon nötr özellik gösterir.

III. Kuvvetli bazların yapısını oluşturan katyonlar asit özelliktedir.

yargılarından hangileri **doğrudur?**

A) Yalnız III

B) I ve II

C) I ve III

D) II ve III

E) I,II ve III

O Bilmiyorum

15. $\mathbf{HS^- (suda) + HF (suda) \rightleftharpoons H_2S(suda) + F^- (suda)}$

Yukarıda verilen tepkime ile ilgili;

I. H_2S bazı, HS^- asidinin konjuge bazıdır.

II. HF bazının konjuge asidi F^-'dir.

III. HS^- ile H_2S konjuge asit/baz çiftidir.

IV. HS^- proton aldığı için bir asittir.

yargılarından hangisi ya da hangileri **doğrudur?**

A) Yalnız III

B) I ve III

C) I, II ve III

D) I, II ve IV

E) Hepsi

O Bilmiyorum

16. Asitlik kuvveti ile ilgili olarak aşağıdakilerden hangisi ya da hangileri **doğrudur?**

I. Merkez atomu aynı olan oksoasitlerin asitlik kuvveti, yapılarındaki oksijen sayısı ile doğru orantılıdır.

II. Merkez atomu farklı olan oksoasitlerin asitlik kuvveti; yapılarındaki halojenlerin elektronegatiflikleri karşılaştırılarak bulunur.

III. Halojen asitlerinde asitlik kuvvetini bulabilmek için; bağ kuvvetlerine bakmamız yeterlidir.

A) Yalnız I

B) I ve II

C) II ve III

D) I ve III

E) I, II ve III

O Bilmiyorum

17. $$Pb_{(k)} + 2HCl_{(suda)} \rightarrow PbCl_{2(suda)} + H_{2(g)}$$

4.14 gram kurşun (Pb) metalini tamamen tepkimeye sokmak için 400 ml HCl çözeltisi kullanılıyor. Buna göre, HCl çözeltisinin **pH** değeri kaçtır? (Pb = 207 g/mol)

A) 0

B) 1

C) 2

D) 3

E) 4

O Bilmiyorum

18. Aşağıda HF, HCl, HBr, HI asitlerini oluşturan elementlerin elektronegatiflikleri verilmiştir. Buna göre; bu asitlerin, **<u>konjuge bazlarının</u>** en kuvvetliden en zayıfa doğru sıralanışı nasıl olmalıdır?

Kimyasal Bağ	Elektronegatiflik
F	4.0
Cl	3.0
Br	2.8
I	2.5
H	2.1

A) $I^{-}>Br^{-}>Cl^{-}>F^{-}$

B) $F^{-} < Cl^{-} = Br^{-} = I^{-}$

C) $I^{-}= Br^{-} = Cl^{-} = F^{-}$

D) $F^{-}>Cl^{-}>Br^{-}>I^{-}$

E) $F^{-}> Cl^{-} = Br^{-} = I^{-}$

O Bilmiyorum

19. Zayıf asitlerle ilgili olarak yapılan aşağıdaki açıklamalardan hangileri **<u>doğrudur?</u>**

I. Zayıf asit çözeltilerinde $[H_3O^+]$ iyonları derişimi, çözeltiyi oluşturan asitin derişimine eşittir.

II. Zayıf asitlerde; asitin başlangıç derişimi arttıkça dengedeki derişimi de artar.

III. Zayıf asitlerde; asitin başlangıç derişimi arttıkça iyonlaşma yüzdesi azalır.

A) Yalnız I

B) I ve II

C) I ve III

D) II ve III

E) I,II ve III

O Bilmiyorum

20.

ASİT	**K_a**
Laktik asit ($HC_3H_5O_3$)	8,3 x 10^{-4}
Hidroflorik asit (HF)	6,3 x 10^{-4}
Formik asit (HCOOH)	1,8 x 10^{-4}

Yukarıda asitlik denge sabitleri verilen asitlerin en kuvvetliden en zayıfa doğru sıralanmış hali aşağıdakilerden hangisinde **doğru** olarak verilmiştir?

A) Laktik asit > Hidroflorik asit > Formik asit

B) Formik asit > Hidroflorik asit > Laktik asit

C) Formik asit > Laktik asit > Hidroflorik asit

D) Hidroflorik asit > Laktik asit > Formik asit

E) Hidroflorik asit > Formik asit > Laktik asit

O Bilmiyorum

21. HA zayıf asidi için asitlik sabiti (K_a) = 5 x 10^{-6} olduğuna göre; 0,2M HA asit çözeltisi için;

I. pH = 3 olur.

II. İyonlaşma yüzdesi % 5 olur.

III. $[A^-]$ = 1x10^{-3} M olur.

yargılarından hangileri **doğrudur?**

A) Yalnız I **B)** Yalnız II **C)** I ve II **D)** I ve III **E)** I,II ve III

O Bilmiyorum

22. 1 M Hidroksil amin ($HONH_2$) çözeltisinin belli sıcaklıkta Kb değeri 2,5 x 10^{-9}'dur. Aynı sıcaklıktaki 1 M piridin (C_5H_5N) çözeltisinin Kb değeri ise 0,1 x 10^{-9} olduğuna göre;

I. Piridinin iyonlaşma yüzdesi hidroksil aminden daha fazladır.

II. Hidroksil aminin OH^- iyon derişimi 5 x 10^{-5}'dir.

III. Piridinin iyonlaşma yüzdesi %0,001'dir.

IV. Piridinin pH değeri 9'dur.

yargılarından hangisi ya da hangileri **yanlıştır?**

A) Yalnız I **B)** II ve IV **C)** II,III ve IV **D)** I ve IV **E)** I,II ve III

O Bilmiyorum

23. Nitröz asidin (HNO_2) Ka değeri 4,0 x 10^{-4} olduğuna göre, bu asidin eşlenik bazı ile eşlenik bazının K_b değeri aşağıdakilerden hangisinde **doğru** olarak verilmiştir?

	Eşlenik baz	K_b değeri
A)	NO_3^-	2,5 x 10^{-12}
B)	NO_3^-	25 x 10^{-12}
C)	NO_2^-	2,5 x 10^{-11}
D)	NO_3^-	4 x 10^{-4}
E)	NO_2^-	25 x 10^{-11}

Bilmiyorum

24. 27°C sıcaklık ve 1,2 atm basınçta 4,1 litre hacim kaplayan HCl gazı 200 ml suda çözünüyor. Buna göre, çözeltinin pH ve pOH değerleri aşağıdakilerden hangisi gibidir? (27°C sıcaklıkta suyun denge sabitinin $1x10^{-14}$ olduğu varsayılacaktır.)

	pH	**pOH**
A)	4	10
B)	1	13
C)	2	12
D)	0	14
E)	14	0

O Bilmiyorum

25. XOH zayıf bazı için 25°C sıcaklıktaki $K_b = 4 \times 10^{-6}$'dır. 0,25 mol XOH'ın 1 litre suda çözünmesiyle hazırlanan çözelti için;

I. İyonlaşma yüzdesi %0,4'dür

II. pH/pOH oranı 3/11'dir.

III. OH^- iyonları derişimi 1×10^{-3}'dür.

yargılarından hangisi ya da hangileri **yanlıştır?**

A) Yalnız I **B)** Yalnız II **C)** I ve II **D)** I ve III **E)** I, II ve III

O Bilmiyorum

26. Tampon çözeltilerle ilgili olarak;

I. Tampon çözeltiler konjuge asit/baz çifti içerir.

II. pH değişimlerine karşı direnç gösteren çözeltilerdir.

III. Zayıf bir asit-kuvvetli bir baz veya zayıf bir baz kuvvetli bir asit titrasyonlarında konjuge asit/baz çifti içeren tampon çözelti oluşur.

IV. İnsan vücudundan tampon çözeltilerin önemi çok büyüktür.

yargılarından hangisi ya da hangileri **doğrudur?**

A) Yalnız IV **B)** I ve III **C)** I,II ve III **D)** I,II ve IV **E)** Hepsi

O Bilmiyorum

27. Aşağıdakilerden hangisi ya da hangileri bir çözeltinin **pH değerini** bulmak için kullanılır?

I. pH metre

II. pH kâğıdı

III. indikatörler

A) Yalnız III **B)** I ve II **C)** I ve III **D)** II ve III **E)** I,II ve III

O Bilmiyorum

28. Aşağıdakilerden hangisi tampon çözeltilerin kullanım alanlarından/görevlerinden biri **değildir**?

A) Biyokimyasal tepkimelerde tepkimenin istenilen yönde ilerlemesini sağlamak.

B) Kandaki pH'ı sabit tutmak.

C) Laboratuvarda yapılan bazı kimyasal tepkimelerde harcanan/oluşan asit ve bazların yan etkisini azaltmak.

D) Böbreklerden asitlerin uzaklaştırılmasını sağlamak.

E) Metabolik olaylar sonucunda ortaya çıkan O_2'yi tamponlamak.

O Bilmiyorum

29. X: Kuvvetli asit – zayıf baz

Y: Zayıf asit – kuvvetli baz

Z: Kuvvetli asit – kuvvetli baz

ile oluşturulmuş tuzlardır. Bu tuzların sulu çözeltileri için,

I. X asidik, Y bazik özellik gösterir

II. Üçü de elektrik akımını iletir

III. Z herzaman nötr özellik gösterir.

yargılarından hangisi ya da hangileri **doğrudur**?

A) Yalnız I **B)** Yalnız II **C)** I ve II **D)** I ve III **E)** I, II ve III

O Bilmiyorum

30. Zayıf bir baz olan amonyum hidroksit (NH_4OH)'in 100 ml 0,1M çözeltisine kuvvetli bir asit olan hidroklorik asit (HCl)'in 100ml, 0,1M'lık çözeltisinden ilave ediliyor. Buna göre; aşağıdakilerden hangisi ya da hangileri **<u>doğrudur</u>**?

I. Baz zayıf olduğundan nötralleşme tam gerçekleşmez.

II. Bu iki madde birbirini tam olarak nötrleştirir.

III. Nötral bir çözelti oluşur.

IV. Ortam asidik olur.

A) Yalnız III **B)** II ve IV **C)** Yalnız II **D)** I ve IV **E)** Yalnız IV

O Bilmiyorum

31. 0,1 M NaOH çözeltisi ile 0,1 M H_3PO4 çözeltisi birbirleriyle titrasyona sokulduğunda, bu iki madde arasında gerçekleşen reaksiyonun denklemi aşağıda verilmiştir:

$$3NaOH(suda) + H_3PO4(suda) \rightarrow Na_3PO4(suda) + 3H_2O(s)$$

Titrasyonun sonunda 120 ml NaOH çözeltisi harcandığına göre harcanan H_3PO4 çözeltisinin hacmi kaç ml'dir?

A) 400 ml **B)** 360 ml **C)** 40 ml **D)** 3,6 ml **E)** 36 ml

O Bilmiyorum

32. Kuvvetli bir asit, zayıf bir baz ile tepkimeye giriyor. Çözeltinin pH değerini bulmak için aşağıdaki indikatörlerden hangisi ya da hangileri kullanılabilir?

İndikatör	**Düşük pH'daki renk**	**pH geçiş aralığı (yaklaşık)**	**Yüksek pH'daki renk**
Fenolftalein	Renksiz	8,2 - 10,0	Mor-menekşe
Litmus	Kırmızı	4,5 -8,3	Mavi
İndigo Karmin	Mavi	11,4 – 13,0	Sarı

A) Litmus
B) İndigo Karmin
C) Fenolftalein – Litmus
D) Litmus – İndigo Karmin
E) Hepsi

O Bilmiyorum

33. Evlerimizde kullanılan çaydanlıkların içerisinde biriken kireci sökmek için genellikle limon tuzu kullanılır. Bunun sebebi aşağıdakilerden hangisidir?

A) Limon tuzu, kireçten daha kuvvetli bir asittir. Bu sebeple kireci sökebilmektedir.

B) Kireç, limon tuzundan daha kuvvetli bir bazdır. Bu sebeple kireci sökebilmektedir.

C) Limon tuzu asit, kireç ise bazdır. Aralarında bir nötralleşme tepkimesi oluşarak kireç sökülmektedir.

D) Limon tuzu baz, kireç ise asittir. Aralarında bir nötralleşme tepkimesi oluşarak kireç sökülmektedir.

E) Limon tuzu ve kireç asittir. Bir asidi ancak başka bir asit çözebildiğinden kireç sökülmektedir.

O Bilmiyorum

SON

APPENDIX D

CHEMISTRY MOTIVATION QUESTIONNAIRE (CMQ)

KİMYA MOTİVASYON ANKETİ

Kimya dersi hakkında ne düşündüğünüzü ve nasıl hissettiğinizi anlamak için lütfen aşağıdaki ifadeleri burada verilen cümleyi dikkate alarak değerlendirip size en uygun olan kutucuğu işaretleyiniz:

"Kimya dersinde olduğum zaman..."

Kız O **Erkek O**

1	2	3	4	5
Hiçbir zaman	**Nadiren**	**Bazen**	**Genellikle**	**Her zaman**

		1	2	3	4	5
1	Kimyayı öğrenmekten hoşlanırım.					
2	Öğrendiğim kimya bilgisi benim kişisel hedeflerimle ilişkilidir.					
3	Kimya sınavlarında diğer öğrencilerden daha başarılı olmak isterim.					
4	Kimya sınavlarının nasıl geçeceğini düşünmek beni endişelendirir.					
5	Eğer kimya öğrenirken zorluk çekersem nedenini bulmaya çalışırım.					
6	Kimya sınavı zamanı geldiğinde endişelenirim					
7	Kimyadan iyi bir not almak benim için önemlidir.					
8	Kimyayı öğrenmek için gerekli çabayı gösteririm.					
9	Kimyayı iyi öğrenmemi sağlayacak stratejiler kullanırım.					
10	Kimyayı öğrenmenin iyi bir iş bulmada bana nasıl yardımcı olacağını düşünürüm.					

11	Öğrendiğim kimya bilgisinin bana nasıl faydası olacağını düşünürüm.					
12	Kimya dersi başarımın diğer öğrenciler kadar veya daha iyisinin olacağını düşünürüm.					
13	Kimya sınavlarında başarısız olmaktan endişelenirim.					
14	Kimya dersinde diğer öğrencilerin daha başarılı olduğunu düşünmek beni kaygılandırır.					
15	Kimya ders notumun genel not ortalamamı nasıl etkileyeceğini düşünürüm.					
16	Benim için kimyayı öğrenmek aldığım nottan daha önemlidir.					
17	Kimya öğrenmenin kariyerime nasıl faydası olacağını düşünürüm.					
18	Kimya sınavlarına girmekten hoşlanmam.					
19	Öğrendiğim kimyayı nasıl kullanacağımı düşünürüm.					
20	Kimyayı anlayamıyorsam bu benim hatamdır.					
21	Kimya laboratuvarında ve projelerinde başarılı olacağımdan eminim.					
22	Kimya öğrenmeyi ilginç bulurum.					
23	Öğrendiğim kimya hayatımla ilişkilidir.					
24	Kimya dersindeki bilgi ve becerileri tam olarak öğrenebileceğime inanırım.					
25	Öğrendiğim kimyanın benim için pratik değeri vardır.					
26	Kimya sınavları ve laboratuvarları için iyi hazırlanırım.					
27	Beni zorlayan kimya hoşuma gider.					
28	Kimya sınavlarında başarılı olacağıma eminim.					
29	Kimya dersinden en yüksek notu alabileceğime inanırım.					
30	Kimyayı anlamak bana başarı duygusu verir.					

APPENDIX E

REFLECTION PAPER

MATERYAL DEĞERLENDİRME FORMU

Bu materyal ile öğrendim/fark ettim ki…

Bu materyalde eksik buldum, …….. hakkında bilgi olmasını beklerdim.

APPENDIX F

OBSERVATION CHECKLIST

SINIF İÇİ GÖZLEM FORMU

KONU : ………………… SINIF : …………..…… TARİH : ……….......

Açıklama: Bu gözlem Listesi, kimya dersinin işlenişini değerlendirmek amacıyla oluşturulmuştur. Bu sebeple, soruların dersin işlenişi göz önüne alınarak değerlendirilmesi önem arz etmektedir. Her cümlenin karşısında "Çok İyi, İyi, Orta, Zayıf ve Çok Zayıf" ve "NA" seçeneği yer almaktadır. Her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz. Teşekkürler.

MADDELER	Çok İyi	İyi	Orta	Zayıf	Çok Zayıf	NA
1. Sınıf ortamı ders yapmaya uygundu.						
2. Öğrenciler derse katılmaya istekli davrandı.						
3. Öğrenciler yeni bilgiler öğrenmeye hevesliydi.						
4. Öğrencilerin, verilen olayları kendi başlarına incelemelerine izin verildi.						
5. Öğrenciler gruplar halinde çalıştılar.						
6. Her bir gruptaki öğrencilere olayların metinlerini okuma fırsatı verildi.						
7. Her bir öğrencinin grup içi tartışmalara katılımı sağlandı.						
8. Öğretmen, öğrencilerin grup içi tartışmalarına müdahale etmedi.						
9. Öğrenciler ders boyunca düzenli olarak not tuttular.						
10. Verilen olayda yer alan sorular gruplarla birlikte cevaplandı.						

11. Her bir öğrenci aktif olarak derse katıldı.						
12. Öğrencilerin verilen olayla ilgili bilinen yanılgılara sahip olup olmadıkları araştırıldı.						
13. Anlaşılmayan noktalar olduğunda açıklığa kavuşturuldu.						
14. Öğretmen öğrencilere merak uyandıran sorular sordu.						
15. Öğretmen öğrencilerin ilgisini çekebildi.						
16. Belirtilen kavram yanılgılarının bilimsel açıklaması yapıldı.						
17. Verilen olaylarda benzetme kullanılmış ise; benzetmelerin konu ile farklılık gösterdiği noktalar açıklandı.						
18. Öğretmen ve/veya öğrenciler mümkün olduğunca günlük hayat üzerinden örnekler verdiler.						
19. Verilen olay üzerinden, ilgili asit-baz kimya konusu açıklandı.						
20. Öğrenciler sürekli bilgi alan bireyler konumunda bulundular.						
21. Öğrencilerin konuyu anlayıp anlamadığına dair düzenli dönüt alındı.						
22. Öğretmen sınıfta kolaylaştırıcı/yönlendirici görevini üstlendi.						
23. Öğretmen kavram öğretimleri sırasında direkt olarak öğrencilere anlattı.						
24. Öğretmen öğrencilerin rahat hissedebileceği bir ortam sağladı.						
25. Öğretmen verilen ders planına uygun davrandı.						

APPENDIX G

EXAMPLES TO THE CASES OF THE STUDY

0. ESKİ DOST

Esra bir akşam ailesi başka bir şehre taşındığı için uzun zamandır göremediği arkadaşı Tuğba'dan gelen arama ile çok mutlu oldu. Aldığı bilgiye gore haftasonu ailesi ile birlikte Ankara'dan Karabük'e geliyorlardı. Bu amaçla, Cumartesi günü öğlen görüşmek üzere plan yaptılar. Esra, o gün arkadaşını uzun süreden sonar göreceği için "güzelce hazırlanmam gerek" dedi kendi kendine. Önce Cumartesi gününün hava durumuna baktı ve ılık bir bahar günü olacağını görünce heyecanla "yeni aldığım elbisemi giyebilicem" diye düşündü. "Yine de en iyisi bir plan yapıp hazırlanmamı buluşma saatimizden önce bitireceğimden emin olayım" diye ekledi. Bir kağıda Cumartesi sabahı yapacaklarını yazdı:

9.00: Uyan ve güzel bir duş al. (o gün hava ılık olmasına rağmen duştan çıkınca titredi)

9.30: Saçlarını tara, kurut ve şekillendir (saçlarını taramak için aynaya baktığında aynanın buhulandığını gördü)

10.00: Dişlerini fırçala (Yerler neredeyse kurumuş olmasına rağmen diş fırçasını koyduğu bardağın altının hala ıslak olduğunu gördü)

10.15: Parfüm sürmeyi unutma! (Parfüm sürerken yere damladığını gördüğü kolonyanın yerdeki su damlalarından çok daha hızlı buharlaştığını gördü)

10.30: Saç spreyiyle saçlarına son şeklini vermeyi ihmal etme! (Esra saç spreyini yerinde bulamadı. Bir süre aradıktan sonra, saç spreyini pencerenin önünde unuttuğunu fark etti ve "iyi ki patlamamış!!!" diye içinden geçirdi)

10.45: Kahvaltı için çay suyunu koy ki kaynasın. (Çay suyunun kaynamasını beklerken Esra kendi kendine "bu baloncuklar nasıl oluşuyor acaba?" diye merak etti. Ayrıca "neden su bu kadar sıcak olasıya kadar oluşmuyorlar acaba?" diye düşündü.)

11.00: Kahvaltını yap.

Esra saat 12.30'da Tuğba ile buluştu ve Tuğba'ya yolculuğunun nasıl geçtiğini sordu. Tuğba, yolda bardaktan boşalırcasına yağan yağmur dolayısıyla biraz endişelendiğini ve yolculuklarının uzadığını anlattı. Bunun üzerine Esra "Canım çok geçmiş olsun! Yalnız ne kadar ilginç! Sabah suyun buharlaşması sonucunda oluşan durumlar beni bayağı düşündürmüşken şimdi de buharlaşan suyun tekrar suya dönüşmesi ile ilgili bir olay dinliyorum!" diye yanıtladı. İki arkadaş, sonrasında bu durum üzerine derin bir sohbete başladılar...

SORULAR

Yukarıda Esra ile Merve'nin buluşmasının anlatıldığı hikayenin içerisinde Esra'ya ait olan bazı bilimsel gerçekler verilmiştir. Sizden verilen metin ve daha önceki bilgileriniz doğrultusunda, sizden arka sayfada yer alan soruları cevaplamanız beklenmektedir. Bu sebeple verdiğiniz cevapların nedenlerini açıklamanız önemlidir:

1. Sizce banyodan çıktığımızda titrememizin sebebi nedir?

2. Sizce banyodan sonra aynenın üzeri neden buğulanır?

3. Sizce yerlerin kurumaya yaklaşmasına rağmen neden bardağımız hep ıslak kalır?

4. Neden yere damlayan parfüm hemen buharlaşırken su buharlaşmaz?

5. Saç spreyi neden pencerenin önünde unutulursa patlama riski taşır?

6. Sizce kaynayan su üzerinde neden baloncuk oluşur ve neden bu baloncuklar ancak su çok sıcak olduğunda oluşur?

7. Buharlaşan suyun dünyaya yağmur olarak dönmesini kimyasal denge ünitesiyle nasıl açıklarsınız?

8. Kimyasal dengeyi etkileyen faktörleri göz önüne alarak sizce hava olaylarında dengeye hangi faktör etkilemektedir? Neden?

9. Kimyasal dengeyi etkileyen diğer faktörler nelerdir?

10. Kimyasal dengeyi etkileyen faktörlerin etkisinin giderilmesi hangi prensip ile açıklanır? Bu prensibi açıklayınız.

11. Çevrenizde gördüğünüz olaylardan kimyasal dengeye örnek olan başka hangi olay vardır?

1.KARATE KIDS

Demir yumruk ve kırmızı kedi lakaplı iki güçlü karate ustası, bir eğitim seminerinde, kendi bilgilerini diğer insanlara aktarmak için bir araya gelirler. Bu iki karate ustasından birinin yumrukları çok güçlüdür. Karşısındaki sporcuya her vuruşu morartıcı etki yapmaktadır. Bu sebeple kendisine, yıllar önce katıldığı müsabakada birinci olduktan sonra "demir yumruk" lakabı verişmiştir. Diğer karate ustasının özelliği ise avuç içlerinin çok güçlü olmasıdır. Rakiplerine hep avuç içlerini kullanarak saldırmakta; dolayısıyla bu karate ustasının da her vuruşu kızartıcı etki yapmaktadır**.** Bu karate ustasına da bu özelliği sayesinde kazandığı birçok müsabakadan sonra "kırmızı kedi" lakabı verilmiştir.

Demir yumruk biraz kötümser bir yapıya sahiptir. Genellikle çok mutsuzdur ve negatif düşünceler içerisindedir**.** Bu sebeple etrafındaki kişilerden pozitif şeyler duymaya ihtiyaç duyar ve etrafındaki insanların iyimser, pozitif duygularını sömürür. Kırmızı kedi ise, demir yumruğun aksine; çok mutlu ve iyimser bir kişiliğe sahiptir. Bu sebeple, her olayda pozitif bir yön bulabilmektedir. Bu karakterinden dolayı, genellikle çevresindeki mutsuz, kötümser, negatif insanlara pozitif düşünce ve duygularını aşılamaya çalışır.

Kırmızı kedi iyimser bir insan olmasına rağmen; çok çabuk öfkelenebilmekte ve bu öfkesi yine çok çabuk geçmektedir. Genellikle kızdığında etrafındaki kişilere söylediği sözlerden dolayı, bu kişilerin yüzleri ekşimektedir. Hatta bu kişiler kırmızı kedinin öfkelendiği anları birbirlerine anlatmak için "haberiniz olsun şu anda tadı çok ekşi" diye belirtmektedirler. Demir yumruk ise genellikle zor öfkelenir ama öfkelendiğinde de biraz kaba kuvvete başvurarak can acıtabilir**.** Bununla birlikte, sinirli olduğu anlarda, uzunca bir süre sakinleşemediği için, ona ulaşmak için çabaladıkça insanın elinden kayıp gidiyormuş gibi bir his yaratmaktadır. Bu sebeple bu öfkeli anlarına şahit olan insanlar, demir yumruk hakkında "bugün yine tadı çok acı ve kendisi de çok kaygan" şeklinde bir benzetme yapmaktadırlar.

Bu iki karate ustasının bir ortak özelliği vardır: blok kırmadaki başarıları. Kırış tekniği gerektiren blok kırma kısaca; üst üste konulmuş bir veya birden fazla bloğun sporcular tarafından dayanıklılık, doğru zamanlama ve yüksek hız özelliklerinin aynı anda kullanılarak tek vuruşta parçalanması tekniğidir. İkisi de bloklara konsantre olarak, tüm iç enerjilerini bloklara kolaylıkla aktarabilmektedirler. Bu sayede de üst üste konulan blok sayısı kaç olursa olsun, hepsini birden kırabilmektedirler. Kendilerine sorulduğunda, demir yumruk; bu başarısını içerisinde biriken tüm negatif elektriği bloklara yöneltmesine bağlarken; kırmızı kedi ise, içerisinde biriken pozitif elektriğini bloklara yöneltmesine bağlamaktadır.

Kırmızı kedinin uzun yıllardır kendisine özel olan avuç içi tekniğini öğrettiği bir öğrencisi vardır. Kırmızı kedi, avuç içi tekniğinin mükemmel olması için, hayat felsefesinin de önemli olduğunu düşünmektedir ve öğrencisine sürekli "her zaman iyimser ol", "hayatta mutlu olmak ve mutlu etmek için yaşa" gibi cümlelerle tavsiyelerde bulunmaktadır. Fakat kırmızı kedinin öğrencisi, aslında iyi bir insan olmasına rağmen, kendisinin kötümser bir yapısı vardır. Buna rağmen öğrenci; avuç içi tekniğinde gerçekten çok iyidir. Bu durum zaman içerisinde kırmızı kedinin düşüncesini değiştirmiş: "hayata iyimser gözlerle bakma yapısını içeren felsefeyi benimsemese de; bir kişi avuç içi tekniğinde iyi olabilir" diye düşünmeye başlamıştır.

Eğitim seminerinde yapılan uzun sohbetlerin arasında, en çok beklenen an gelmiştir ve demir yumruk ile kırmızı kedi hayatlarında ilk defa birbirleriyle karate yapmaya başlamışlardır. Karate biraz da şov amaçlı olduğu için on beş dakika içerisinde en yüksek puanı hangisi alırsa o yenmiş sayılacaktır ama dolan süreye rağmen bir türlü yenişememişlerdir. Birbirlerini yenmek amacıyla çok çabaladıkları için sadece terlemişlerdir ve vücutlarından bolca tuz ve su atmışlardır. Bu sebeple maçtan sonra biraz dinlenmeye; eğitim sonrasında hayranlarıyla yapacakları oturumu biraz geciktirmeye karar vermişlerdir.

Sizden okuduğunuz bu hikâyeyi dört kişilik gruplar halinde değerlendirmeniz ve aşağıdaki soruları cevaplamanız beklenmektedir:

SORULAR:

1. 8. sınıftaki bilgilerinizden yararlanarak siz çalışma yaprağında okuduklarınızla kimyanın "Asitler ve bazların genel özellikleri" konusunu nasıl ilişkilendirirdiniz? Neden?

2. Sizce parçanın sonunda kımızı kedi niçin felsefesini değiştiriyor? Bu durum kimyanın asit-baz teorilerinde olabilir mi? Neden?

3. Sizce bir asit/baza ne zaman kuvvetli ya da zayıf denir?

4. Lütfen daha önceki bilgilerinize kullanarak, aklınıza gelen 3 adet asit ve 3 adet baz örneği veriniz:

Asit	Baz
1.	**1.**
2.	**2.**
3.	**3.**

a. Bu asitlerden hangisi/hangileri kuvvetli asittir? Neden?

b. Bu asitlerden hangileri kuvvetli bazdır? Neden?

c. Sizce asit/bazların kuvvetli ya da zayıf olması özelliklerini etkiler mi? Neden?

5. Asitler ve bazların buradaki örnekte belirtilmeyen başka genel özellikleri var mıdır? Varsa bunlar nelerdir?

2. GÜNLÜK HAYATIMIZDA YER ALAN ASİT VE BAZLAR

Aşağıda Merve ve üç arkadaşına öğretmenleri tarafından okumaları için dağıtılan metin verilmiştir. Merve ve arkadaşlarının bu metni okuyarak; verilen soruları cevaplamaları beklenmektedir:

Günlük hayatımızda birçok gıdada **doğal olarak** bulunan asit ve bazlara rastlarız. Bunların bazıları ve kullanıldıkları yerler şöyledir:

Asit	Özellikleri	Bulundukları yerler
Benzoik asit	Beyaz renkli iğne ve yaprakçık görünümünde bir maddedir.	Birçok bitkinin yaprak, kabuk ve meyvelerinde
Formik Asit	Karınca asidi olarak bilinen tek karbonlu organik asittir.	Isırgan otunda
Laktik asit	Çeşitli mikroorganizmaların fermantasyonu sonucunda oluşan organik bir bileşiktir.	Yoğurtta
Malik asit	Elmaya ekşi tadını veren organik bir asittir.	Elmada
Sitrik Asit	Çeşitli mikroorganizmaların fermantasyonu sonucunda oluşan organik bir asittir.	Turunçgillerde
Guanin ve guanin içeren bileşikler	Azotlu bazlar arasında yer alan, DNA ve RNA nükleik asitlerinde bulunan organik bileşiktir.	Balıkların pullarında, memelilerin karaciğer ve pankreasında

Gıdalarımızda yer alan bu asit ve bazların tüketilmesinde bir sorun yoktur. Bununla birlikte; **yapay yollarla** üretilen **aynı asitlerin ve/veya bazların** yenilip içilmesi, bazı durumlarda tehlike arz edebilir. Bunun en güzel örneğini satın aldığımız ürünlerin üzerinde, içindekiler kısmında yer alan koruyucu katkı maddelerinde görebiliriz:

Koruyucu Katkı Madde (Yapay)	Kullanıldığı Yer	Sağlığa zararı
E-210 Benzoik Asit	Fırın mamulleri, peynir, çeşni, dondurulmuş mandıra ürünleri, yumuşak tatlılar, kozmetik ürünler, eczacılık	Astım, sinirsel bozukluk ve çocuklarda hiperaktiviteye yol açabilir.
E-236 Formik Asit	Arıcılık, gıda sanayii, ilaç sanayii, deri sanayii, tekstil sanayii, plastik sanayii, çelik sanayii, kâğıt sanayii	Yüksek konsantrasyonları vücutta fazla su kaybına neden olur ve bölgesel olarak alerjik reaksiyonlar oluşabilir.
E-270 Laktik asit	Gıda sanayiinde aroma maddesi, eczacılık, tatlılar, salata sosu, bebe maması, şekerlemeler	Henüz laktatın bu formlarını metobolize edebilecek uygun enzimler karaciğerde gelişmediği için bebeklerin sindirimi için tehlikelidir.
E-296 Malik Asit	Yumuşak içecekler ve konsantratları, kuru içecekler, kabartıcı ürünler, reçel, meyveli sakızlar, fırın ürünleri, konserve meyve ve sebze ürünleri	Küçük çocuklarda ve bebeklerde, metobolize etme kapasitesi olmadıkları için sindirimleri tehlike oluşturur.
E-330 Sitrik Asit	Gofret, meyve suları, bazı hazır çorbalar, teneke konserve turşular, bazı hazır yaprak sarmaları, bazı şekerlemeler	En tehlikeli kanserojen etki maddesidir.
E-626, E-627, E-629 Guanin içeren bileşikler	Lezzet zenginleştiricisi, plastik, metalik boya ve sahte incilerde parlaklık ve renk vericisi, kozmetik endüstrisi	Bebekler, astımlı insanlar ve gut rahatsızlığı yaşayan insanlar için tehlikelidir.

ÖNEMLİ NOT: Burada görülen asit ve bazların dışında, sağlığa zararı olan ya da olmayan; farklı görevleri ve kullanım alanları olan, kimisi doğada kendiliğinden var olurken, kimisi sadece sentezlenen ve/veya gıdalarımızda yer alan birçok farklı asit (HCl, H_2SO_4, HNO_3, HCN, CH_3COOH, HF, vb.) ve baz (NaOH, KOH, $Ca(OH)_2$, $Mg(OH)_2$, $Al(OH)_3$, NH_3, vb.) daha vardır. Bunların da yine bir kısmı doğal haliyle veya suni yollarla üretilerek koruyucu katkı maddesi olarak kullanılmaktadır. Bu sebeple tüm katkı maddeleri zararlıdır demek doğru değildir.

Merve ve arkadaşları bu metni okumuşlar fakat dersleri ilgiyle takip etmedikleri için aşağıdaki soruları cevaplayamamışlardır. Verilen metin ve daha önceki bilgileriniz doğrultusunda, sizden aşağıda Merve ve arkadaşlarına verilen bu soruları dörder kişilik gruplar oluşturarak cevaplamanız ve onlara yardım etmeniz beklenmektedir. Bu sebeple verdiğiniz cevapların nedenlerini açıklamanız önemlidir.

SORULAR:

1. Yukarıdaki metne ve daha önceki bilgilerinize göre aşağıdaki soruları kendi yorumunuzu da katarak cevaplayabilir misiniz?

a. Sizce asitler yararlı mıdır, zararlı mıdır yoksa her ikisi de olabilir mi? Nedenini bir örnekle açıklayınız.

b. Sizce meyveler/sebzeler asidik olabilir mi? Nedenini bir örnekle açıklayınız.

c. Sizce tüm asitler yenilebilir mi? Nedenini bir örnekle açıklayınız.

2. Yukarıda asitler için cevapladığınız üç şıkkı, **kendi yorumunuz doğrultusunda** bazlar hakkında da cevaplayabilir misiniz?

a. Sizce bazlar yararlı mıdır, zararlı mıdır yoksa her ikisi de olabilir mi? Nedenini bir örnekle açıklayınız.

b. Sizce meyveler/sebzeler bazik olabilir mi? Nedenini bir örnekle açıklayınız.

c. Sizce tüm bazlar yenilebilir mi? Nedenini bir örnekle açıklayınız.

3. Sizce tüm asitler için, katkı maddeleri olarak kullanıldığında "insan sağlığına zararlıdır" denilebilir mi? Neden?

4. Aşağıdaki tabloyu yukarıdaki bilgiler ve cevaplarınız doğrultusunda doldurunuz:

	Doğru	**Yanlış**	**Bilmiyorum**
Meyvelerin tadında asitliğin ve/veya bazlığın etkisi vardır.			
Tüm asit ve bazlara dokunulabilir.			
Bazı bazlar ve asitler organiktir.			
Tüm bazlar yararlıdır.			
Tüm katkı maddeleri sağlığa zararlıdır.			
Bazı asitler zehirlidir.			
Asit ve bazların sanayide kullanımı sadece yapay üretim yoluyla olur.			
Sebzeler asidik özellik gösterdiklerinden acımsı tattadırlar.			
Yapay asitlerin bir kısmı insanlara ciddi zararlar verirler.			
Tüm asitler zararsızdır.			
Meyveler bazik özellikte olduklarından ekşi tattadırlar.			
Tüm bazlar zararsızdır.			
Tüm asit ve bazlar tadılabilir.			
Meyvelerin tümü asidik özelliktedirler.			
Tüm asitler yararlıdır.			
Bazı asitler sağlığımıza zararlıdır.			

5. Aşağıda sizler için bir liste verilmiştir. Bu listede, yapılarında asit/baz olan meyve ve sebzelerle; kanımızı asidik ve bazik yapan sebze ve meyvelerden bazıları görünmektedir. Buradaki sebze ve meyvelerin bir kısmı; normalde yapılarında asit olmasına rağmen, kanı bazik yapmakta veya normalde yapılarında baz olmasına rağmen kanı asidik yapmaktadır. Sizce bunun nedeni nedir? Kendi fikirlerinizi birkaç cümle ile açıklayınız.

	Yapılarında Asit Bulunan Sebze ve Meyveler	**Yapılarında Baz Bulunan Sebze ve Meyveler**
Kanı Bazik Yapan Sebze ve Meyveler	Limon, karpuz, kavun, üzüm, armut, kayısı, havuç, portakal, şeftali, çilek, soğan, domates, susam tohumu, patlıcan, greyfurt, mandalina, kivi, ananas, incir, kabak, elma, kuş üzümü, turşu	Muz, hurma, sarımsak, ıspanak, taze fasulye, brokoli, lahana, biber, patates, mısır, badem, salatalık, Karaturp, pazı, nane, zerdeçal, badem, marul
Kanı Asidik Yapan Sebze ve Meyveler	Un, buğday, şeker, pirinç, erik, yabanmersini, ceviz, ekmek, margarin, mayonez, ketçap, ceviz, fındık, nar, yeşil zeytin, kahve, çikolata, peynir	Yumurta, kırmızı et, beyaz et, balık, olgun zeytin

11. BİTKİLER ve TUZLAR

“Bir bitki nasıl yetiştirilir?” paneline katılan bir grup genç; farklı bitkilerin hangi koşullarda yetiştirildiğini anlatan bir listeyi ve bu bitkilerin besin tuzları ile ilişkisini anlatan makaleyi incelemektedirler:

ÇEŞİTLİ BİTKİLERİN YETİŞME KOŞULLARI

Bitki	Sevdiği Sıcaklık	Sevdiği Toprak pH Değeri	Sevdiği Işık Miktarı	Sevdiği Nem miktarı
 Yabanmersini	Yüksek Sıcaklık (min. 10-16°C)	4,5 - 5,5	Tam Güneş	Çok nemli
 Çanta Çiçeği	Düşük Sıcaklık (min. 3-10°C)	5,5 – 6,5	Hafif Gölge	Çok nemli
 Kalp kalbe karşı	Yüksek Sıcaklık (min. 16-20°C)	6,5 - 7,5	Tam Güneş	Orantılı nem
 Leylak	Orta Sıcaklık (min. 10-16°C)	7,0 - 7,5	Tam Güneş	Düşük nem
 Kauçuk	Yüksek Sıcaklık (min. 16-20°C)	7,0 - 8,0	Tam Gölge	Çok nemli
 Kanarya out	Düşük Sıcaklık (min. 3-10°C)	7,5 – 8,0	Hafif Gölge	Nemsiz, Kuru hava

TOPRAK pH’ı VE BESİN TUZLARI İLİŞKİSİ

Tarım topraklarının büyük bir kısmında; pH değeri 5 ila 8,5 arasındadır. Bitkilerin hangi pH sınırları arasında yetiştiği bilinirse, toprak pH’ı ile karşılaştırılarak durum değerlendirilmesi yapılabilir. Gerekli durumlarda toprak pH’ı yükseltilip düşürülebilir.

Toprağın pH değerinin çok yüksek (8,0’den fazla) veya çok düşük (5’den düşük) olması, bitki kökleri tarafından besin elementlerinin alınması üzerine çok etkilidir. Örneğin; pH oranı çok düşük toprakta bulunan her bitki belli sinyaller verir. Bitkinin alt kısmı normal kalsa da diğer kısımlarında sararma ve deformasyonlar görülür ve bitki büyüme sorunları yaşar. Bu kök gelişimini de etkiler, kök kısa ve güdük kalır. Aynı şekilde, pH oranının yüksek olduğu kireçli topraklarda da yine bitkide sararma, solma gibi çeşitli sorunlar görülecektir.

pH değerinin 5 ila 8,5 arasında olduğu, çok yüksek veya çok düşük olmadığı hafif asidik veya bazik topraklarda ise bitkiler toprak tercihlerine göre yetişebilirler. Burada unutulmaması gereken; toprağın pH değerinin düşük ya da fazla olmasının toprak içerisinde çözünen besin elementlerinden kaynaklandığıdır. Bir başka deyişle; besin elementlerini içinde barındıran tuzların karakteri; aynı zamanda toprağın asidik, bazik ya da nötr olmasını sağlar.

Tablo 1: Toprakta Bulunan Çeşitli Tuz Çözeltileri ve Bunların Oluşumları

Çeşitli Tuz Çözeltileri	Tuz Çözeltilerinin Oluşumları
NH_4Cl	NH_4OH(suda) + HCl(suda) → NH_4Cl(suda) + H_2O (s)
CH_3COONa	CH_3COOH (suda) + NaOH (suda) → CH_3COONa(suda) + H_2O (s)
$FeCl_3$	3 HCl (suda) + $Fe(OH)_3$(suda) → $FeCl_3$(suda) + 3 H_2O (s)
$CuSO_4$	H_2SO_4(suda) + $Cu(OH)_2$(suda) → $CuSO_4$(suda) + $2H_2O$(s)
NaCN	NaOH (suda) + HCN (suda) → NaCN (suda) + H_2O(s)
KNO_3	HNO_3(suda) + KOH(suda) → KNO_3(suda) + H_2O(s)
KNO_2	HNO_2 (suda) + KOH(suda) → KNO_2(suda) + H_2O(s)
$Al(NO_3)_3$	$Al(OH)_3$ (suda) + $3HNO_3$ (suda) → $Al(NO_3)_3$(suda) + 3 H_20 (s)
$MgCO_3$	H_2CO_3(suda) + $Mg(OH)_2$(suda) → $MgCO_3$(suda) + 2 H_2O(s)
$MnCl_2$	$Mn(OH)_2$ (suda) + 2HCl (suda) → $MnCl_2$ (suda) + 2 H_2O (s)
$Al(OH)_2Cl$	$Al(OH)_3$ (suda) + HCl (suda) → $Al(OH)_2Cl$(suda) + H_2O(s)
$CaSO_4$	H_2SO_4(suda) + $Ca(OH)_2$(suda) → $CaSO_4$(suda) + 2 H_2O(s)
$ZnCl_2$	$Zn(OH)_2$(suda)+ 2HCl (suda)→ $ZnCl_2$(suda) + 2 H_2O (s)
K_3PO_4	KOH (suda) + H_3PO_4 (suda) → K_3PO_4 (suda) + H_2O(s)

Panelde görev alan eğitmen katılımcılardan, verilen listede yer alan bitkilerin makalede verilen özelliklerine göre; Tablo 1’de yer alan tuzlardan hangisine ulaşıp ulaşamayacağını ve bunun sebebini araştırmalarını istemiştir. Sizden, bu panele katılan gençlerden biri olduğunuzu varsaymanız ve arkada belirtilen soruları cevaplamanız beklenmektedir.

Arka Plan Bilgi:

Tuz, bir asitle bir bazın tepkimeye girmesi neticesinde meydana gelen maddedir. Tuz; bazdaki artı yüklü iyonla (katyonlar) asitteki eksi yüklü iyondan (anyonlar) meydana gelir. Dolayısıyla; çözelti halindeki tuzların çoğu eksi ile artı yüklü iyonlarına ayrışır ve elektriği iletir.

Tuzlar, çeşitli şekilde sınıflandırılabilir. Sınıflandırmalardan biri, tuzun bünyesinde OH^- veya H^+ iyonunun olup olmayışına bağlıdır. Bu sınıflandırmada tuzlar normal, asidik ve bazik tuzlar şeklinde sınıflandırılır.

Asidik tuzlar: Asidik tuzlar, bünyelerinde bir veya daha çok H^+ iyonu bulunduran tuzlardır. Suda çözündükleri zaman bünyelerindeki H^+ iyonunu vererek ortamı asidik yapar. $NaHCO_3$, NaH_2PO_4 ve $NaHSO_4$ birer asidik tuzdur.

Bazik tuzlar: Bazik tuzlar, bünyelerinde en az bir OH^- iyonu bulunduran tuzlardır. Suda çözündükleri zaman ortamı bazik yaparlar. $Pb(OH)Cl$ ve $Al(OH)_2Cl$'de olduğu gibi.

Tuzların sudaki çözünürlüklerinin asidik mi, bazik mi yoksa nötr mü olduğunu anlamak için aşağıdaki kuralları uygulayabiliriz:

***1)** Kuvvetli asit ile kuvvetli bazın oluşturduğu tuzlar: Tuzun iyonları suyla tepkime vermezler. Oluşan çözelti bu yüzden nötrdür. (örnek: NaCl). Kuvvetli asitlerin anyonları (ör: Cl^-, Br^-, I^-, NO_3^-, ClO_4^- vb.) ile kuvvetli bazların katyonları (ör: Li^+, Na^+, K^+, Ca^{2+}, Ba^{2+}, Sr^{2+} vb.) nötr özellikteki tuzların anyon ve katyonlarıdır.*

***2)** Kuvvetli baz ve zayıf asidin oluşturduğu tuzlar: Tuzun çözeltideki negatif iyonu (anyonu), zayıf asidin konjuge iyonudur. Suyla tepkimeye girer ve bazik karakterli çözelti oluşturur. (örnek: NaCN). Zayıf asitlerin anyonları (ör: F^-, CH_3COO^-, $ClOHCOO^-$,CN^-, NO_2^-) ile çok protonlu asitlerin çoğu anyonları (ör: HCO_3^-, HS^-, HCO_3^-, $HPO4^{-2}$, CO_3^{-2}, SO_4^{-2}, $SO3^{-2}$, S^2, PO_4^{-3}) bazik özellikteki tuzların anyonlarıdır. **Bazik katyonlar ise yoktur**).*

***3)** Zayıf baz ile kuvvetli asitin oluşturduğu tuzlar: Tuzun, çözeltideki pozitif iyonu (katyonu), zayıf bazın konjuge iyonudur. Suyla tepkimeye girer ve asit karakterli çözelti meydana gelir. (örnek: NH_4Cl). Bazı çok protonlu asitlerin anyonları (ör: HSO_4^-, $H_2PO_4^-$, HSO_3^-) ile zayıf bazların katyonları (ör: NH_4^+) ve bazı metal katyonları (ör: Al_3^+ ve geçiş metal iyonları) ve asidik özellikteki tuzların anyon ve katyonlarıdır.*

***4)** Zayıf baz ve zayıf asitlerin oluşturduğu tuzlar: Tuzun çözeltideki iki iyonu da (anyonu ve katyonu) suyla tepkime verir. Bu durumda çözeltinin asidik mi yoksa bazik mi olacağı, bu anyon ve katyonların kendi aralarındaki asit-baz kuvvetliliğine bağlıdır. Buna karar vermek için katyonun Ka değerine ve anyonun Kb değerine bakarız. Hangisi daha büyükse çözeltiye o karakter hâkim olur.*

Genel olarak dikkat etmemiz gereken bir diğer husus ise; çapı küçük, yükü büyük metal katyonlarının asidik özellik gösterdiğidir. (Fe^{+3}, Al^{+3}, Cu^{+2}). Ayrıca; tüm Grup 1 ve Grup 2 metalleri (örneğin Li^+, Ca^{+2}) ile +1 yüklü tüm metal katyonları (örneğin, Ag^{+1}) nötraldir.

SORULAR:

1. Yukarıda size verilen “toprakta bulunan toprakta bulunan çeşitli tuz çözeltileri ve bunların oluşumları tablosunda” (Tablo 1) ne tip asit ve bazların, verilen tuzların oluşumunu sağladığını göz önünde bulundurarak; aşağıda verilen tuzların karakterlerini (asidik, bazik, nötr) belirleyiniz.

Çeşitli Tuz Çözeltileri	Kuvvetli Asit + Kuvvetli Baz	Zayıf Asit + Kuvvetli Baz	Zayıf Baz + Kuvvetli Asit	Zayıf Asit + Zayıf Baz	Tuzun Karakteri
NH_4Cl					
CH_3COONa					
$FeCl_3$					
$CuSO_4$					
NaCN					
KNO_3					
KNO_2					
$Al(NO_3)_3$					
$MgCO_3$					
$MnCl_2$					
$Al(OH)_2Cl$					
$CaSO_4$					
$ZnCl_2$					
K_3PO_4					

2. Yukarıdaki bilgiler ışığında, her bir bitkinin Tablo 1’de verilen tuzların içerisinden hangi besin tuzlarına kolaylıkla ulaşabileceği ve ulaşamayacağını belirleyerek aşağıdaki tabloya yazınız.

Bitki	Ulaşabileceği Tuzlar	Ulaşamayacağı tuzlar
Maviyemiş		
Çanta Çiçeği		
Kalp Kalbe Karşı		
Leylak		
Kauçuk		
Kanarya otu		

a. Neden bu şekilde düşündüğünüzü lütfen açıklayınız.

3. Tablo 1'de verilen bu tuzların su ile tepkimelerini gösteren tabloyu doldurunuz.

Çeşitli Tuz Çözeltileri	**Tuzun Suda Çözünmesi**
NH_4Cl	
CH_3COONa	
$FeCl_3$	
$CuSO_4$	
NaCN	
KNO_3	
KNO_2	
$Al(NO_3)_3$	
$MgCO_3$	
$MnCl_2$	
$Al(OH)_2Cl$	
$CaSO_4$	
$ZnCl_2$	
K_3PO_4	

4. Tablo 1'de verilen bu tuzların kendisi, katyon ve anyonları ile bunların karakterlerini gösteren tabloyu doldurarak birinci sorudaki cevabınız ile karşılaştırınız.

Çeşitli Tuz Çözeltileri	**Katyon ve Katyonun karakteri**	**Anyon ve Anyonun Karakteri**	**Tuzun Karakteri**
NH_4Cl			
CH_3COONa			
$FeCl_3$			
$CuSO_4$			
NaCN			
KNO_3			
KNO_2			
$Al(NO_3)_3$			
$MgCO_3$			
$MnCl_2$			
$Al(OH)_2Cl$			
$CaSO_4$			
$ZnCl_2$			
K_3PO_4			

a. İki tablo arasında tuzun karakteri açısından bir fark oldu mu? Sizce neden?

5. Tablo 1'de verilen tuzların anyon ve katyonlarının konjuge asit/bazlarını yazınız.

Çeşitli Tuz Çözeltileri	**Katyon ve Konjuge Bazı**	**Anyon ve Konjuge Asiti**
NH_4Cl		
CH_3COONa		
$FeCl_3$		
$CuSO_4$		
NaCN		
KNO_3		
KNO_2		
$Al(NO_3)_3$		
$MgCO_3$		
$MnCl_2$		
$Al(OH)_2Cl$		
$CaSO_4$		
$ZnCl_2$		
K_3PO_4		

6. Beşinci soruda belirlediğiniz katyonların konjuge bazlarının kuvvetli/zayıf olduğunu, doğru olduğunu düşündüğünüz kısma çarpı (X) işaretini koyarak not ediniz.

Çeşitli Tuz Çözeltileri	**Katyonun Konjuge Bazı**	**Kuvvetli Baz**	**Zayıf Baz**
NH_4Cl			
CH_3COONa			
$FeCl_3$			
$CuSO_4$			
NaCN			
KNO_3			
KNO_2			
$Al(NO_3)_3$			
$MgCO_3$			
$MnCl_2$			
$Al(OH)_2Cl$			
$CaSO_4$			
$ZnCl_2$			
K_3PO_4			

7. Beşinci soruda belirlediğiniz <u>anyonların konjuge asitlerinin</u> kuvvetli/zayıf olduğunu, doğru olduğunu düşündüğünüz kısma çarpı (X) işaretini koyarak not ediniz.

Çeşitli Tuz Çözeltileri	**Anyonun Konjuge Asiti**	**Kuvvetli Asit**	**Zayıf Asit**
NH_4Cl			
CH_3COONa			
$FeCl_3$			
$CuSO_4$			
NaCN			
KNO_3			
KNO_2			
$Al(NO_3)_3$			
$MgCO_3$			
$MnCl_2$			
$Al(OH)_2Cl$			
$CaSO_4$			
$ZnCl_2$			
K_3PO_4			

8. Verilen bilgilerden ve önceki bilgilerinizden yola çıkarak; tabloda belirtilen tuzlardan hangileri **<u>anyonu zayıf baz olan tuzlara</u>** örnektir? Neden?

9. Yukarıdaki bilgilerden yola çıkarak; tabloda belirtilen tuzlardan hangileri **<u>katyonu yüksek pozitif yüklü (+2,+3 vb.) ve anyonu nötral asidik tuzlara</u>** örnektir? Neden?

10. Panele katılan öğrencilerden Kemal'in, babası ile ilgili aşağıdaki soruları cevaplayınız:

a. Kemal'in babası, toprakla ilgilenmeyi çok sevmektedir. Bu sebeple, toprağının pH değeri 7,0 olan evinin bahçesinde çeşitli bitkileri yetiştirmeye karar vermiştir. Kemal'in babasının yukarıda verilen bitkilerin her birini bu bahçede yetiştirmek istediğini varsayarsak; her bir bitki için aşağıdaki tabloda verilen maddelerden hangisi ya da hangilerini kullanmak doğru olur?

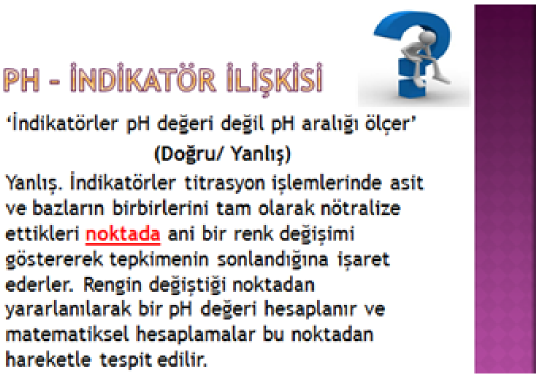
Toprağa eklenen madde	**pH Düşürücü**	**pH Artırıcı**
Amonyum sülfat içeren gübre eklemek	X	
Dolomit eklemek		X
Kireç eklemek		X
Sülfür eklemek	X	

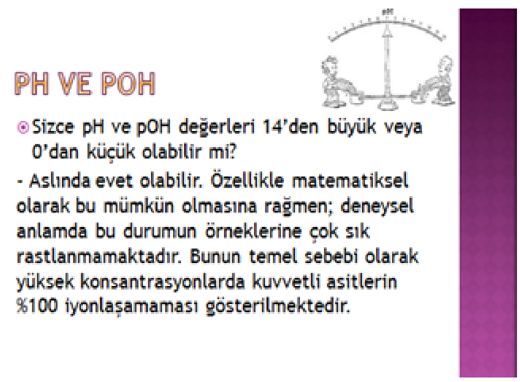
b. Kemal'in babasının evi <u>çok nemli</u> ve <u>çok güneşli</u> bir yörede yer aldığına göre; toprak doğru pH değerine getirildikten sonra, hangi bitki en düzgün şekilde yetişecektir?

11. Yukarıdaki bilgilerden yola çıkarak; sizce <u>zayıf baz</u> ve <u>zayıf asitlerin</u> birleşerek oluşturduğu tuz çözeltilerinin asidik mi yoksa bazik mi olacağını başka neleri bilerek cevaplayabilirdik?

APPENDIX H

SOME SLIDES USED IN THE PRESENTATION





APPENDIX I

EXAMPLE OF A LESSON PLAN USED IN EXPERIMENTAL GROUPS

DENEY GRUBU DERS PLANI 1. HAFTA

BÖLÜM 1

Dersin adı: Kimya

Sınıfı: 11

Ünite Adı: Çözeltilerde Denge

Konu: Asitler ve Bazların Genel Özellikleri

Önerilen Süre: 135 dk. (3 ders saati)

BÖLÜM 2

İlgili Kazanımlar:

- ✓ Asit ve bazları; dokunma, tatma ve görme duyuları gibi özellikleri ile tanır.
- ✓ Kuvvetli /zayıf asitlerin genel özelliklerini bilir.

Ön Bilgiler:

- 8. Sınıf Asitler, bazlar, tuzlar ünitesi

BÖLÜM 3

Dersin Akışı:

Birinci Ders

- ✓ Öğretmen sınıfa girdikten ve öğrencileri selamladıktan sonra, onlara bir çalışma yaprağı dağıtacağını ve öğrencilerin dörder kişilik gruplar oluşturarak, bu çalışma yapraklarini okumalarını söyler.
- ✓ Öğrenciler 4-5 kişilik gruplar oluşturduktan sonra; öğrencilere "Karate Kids" isimli çalışma yaprağı dağıtılarak; öğrencilere bu çalışma yaprağını okumaları için süre verilir.
- ✓ Öğrencilerden okudukları çalışma yaprağındaki örnek olaydan yararlanarak arka sayfada verilen soruları cevaplamaları istenir.
- ✓ Verilen soruları cevaplayan gruplardan birer sözcü seçmeleri istenir.

- ✓ Öğretmen bir grubun sözcüsünden soruya verdiği cevabı alır. Sözcünün cevabının ardından “neden böyle düşündün?, arkadaşınıza katılmayan var mı?, başka fikri olan var mı?” gibi sorularla diğer sözcülerin fikirlerini alarak, sınıf ile birlikte her soru için doğru cevapları oturtmaya çalışır. Bu sırada grupların fikirleri tahtaya yazılır.

<u>İkinci Ders</u>

- ✓ Ders arasından sonra öğretmen öğrencilerin toparlanması için onlara süre verir
- ✓ Öğretmen öğrencilerinden tahtada yazılı olan öğrenci cevplarını bir kez daha okumalarını ister. Öğrencilere eklemek istedikleri şeyler olup olmadığı sorulur.
- ✓ Öğretmen öğrenci cevaplarının tek tek üzerinden geçerek öğrencilerle her bir yanıtı tartışır. Bu sırada öğrencilere katılıp katılmadıkları ve sebepleri sorulur.
- ✓ Öğretmen yeri geldikçe vurgulanacak kavram yanılgılarını vurgular, bilimin doğası ile ilgili sorular sorarak onlara bilimin doğasına ait olan bilimin değişebilirliğini anlatır.
- ✓ Öğretmen; öğrenci cevaplarından da yararlanarak; asit ve bazların genel özelliklerini toparlar, öğrencilerle birlikte kavramsal özet yapar.
- ✓ Öğretmen öğrencilere anlaşılmayan bir şey olup olmadığını sorar, sorusu olan öğrencilerin sorularını cevaplar.
- ✓ Yapılan tüm özetlemeden sonra; öğretmen, çalışma yapraklarının sonunda yer alan öğrencilerin değişen fikirlerini, beklentilerini, öğrendiklerini yazdıkları kısmın doldurulması ister.
- ✓ Son olarak, öğrencilere veda edip, dersi bitirir.

<u>Üçüncü Ders</u>

- ✓ Öğretmen öğrencilerin derse hazırlanması için onlara zaman verir.
- ✓ Öğretmen öğrencilerine asit ve bazların genel özellikleri ile ilgili kavram yanılgılarından daha geniş bir şekilde bahseder.
- ✓ Bilimin doğası ile ilgili sınıf içi bir tartışma ortamı yaratarak bu ortamı yönetir.

- ✓ Öğrencilerindaha kolay hatırlayabilmesi, öğrenebilmesi ve ilgilerini çekmesi için analojiden yararlanılarak hazırlanan bu örnek olayın analoji ile örtüşen ve ayrışan kısımlarını açıklar.
- ✓ Öğretmen öğrencilerin anlamadıkları yerler olup olmadığını düzenli olarak sorgulayarak, gerekli yerlerde açıklamalar yapar ve öğrencilerin sorularını cevaplar.
- ✓ Öğretmen öğrencilere veda edip, dersi bitirir.

Etkinliğin Amacı

Öğrencilerin 8. Sınıfta gördükleri asit ve bazların genel özellikleri konusu ile ilgili ön bilgilerini ortaya çıkartmak ve bu konuyu hatırlamalarını sağlamak.

Etkinlik Öncesi Yapılacaklar:

- ✓ Öğrencilerin 4-5 kişilik küçük gruplar oluşturmaları sağlanır.
- ✓ Öğrencilere asit ve bazların genel özellikleri ile ilgili hazırlanan "Karate Kids" isimli çalışma yaprakları dağıtılır.

Etkinlik Sırasında Yapılacaklar:

a. Öğretmen

Öğretmen ders boyunca **yönlendirici** olarak görev yapar. Öğrencilerin ne zaman ne yapması gerektiği konusunda öğrencileri yönlendireceği gibi, öğrenciler bir soruyu cevaplamakta zorlandıklarında veya sorulara verilen cevaplar sınıfça tartışılırken, çıkan fikir ayrılıklarında, doğru cevaba yönelik sorularla çocukların bu cevaplara ulaşmasını sağlamakla yükümlüdürler.

- ➢ Öğretmenin etkinlik içerisinde **bilimin doğasına** vurgu yapması beklenmektedir. Burada özellikle genel anlamda bilimin doğasından bahsedilmesi ve ardından özellikle bu olayla (case ile) ilişkili olarak bilimin değişebilirliğine vurgu yapılması önem arz etmektedir.

b. Etkinliğe katılma

Oluşturulan gruplardan her biri çalışma yapraklarında verilen olayı anlamaya çalışır. Gruptan tek bir kişinin çalışma yaprağını okuyarak soruları cevaplaması istenmeyen bir davranıştır. Bu sebeple, öğretmen bu durumla karşılaşır ise, grubu uyarmalıdır.

c. Fikirleri Paylaşma

- Öğrencilerden onlara verilen okuma parçasını okumaları ve bununla ilgili verilen soruları cevaplandırmaları istenir. Öğrenciler etkinlik sırasında onlara verilen soruları birbirleriyle tartışarak ortak bir cevap bulurlar ve bu cevaplarını çalışma yapraklarına kaydederler. Bu sebeple; her grup ortak bir cevap konusunda uzlaşmaya çalışır.
- Her grup çalışma yapraklarındaki soruları da cevapladıktan sonra öğretmen yönetiminde fikirlerini diğer gruplarla paylaşır. Bunun için her grup bir sözcü seçerek, kendi cevaplarını ve neden bu şekilde cevapladıklarını yorumlayarak arkadaşlarına açıklamaya çalışır. Bu sırada öğretmen ve/veya öğrenciler gruba sorular sorabilir ve tüm sınıfın katıldığı bilimsel tartışma ortamı sağlanmış olur.

Etkinlik Sonunda Yapılacaklar:

Bu etkinlik ile öğrencilerin asit-bazların genel özellikleri konusunu hatırlamaları ve eksik bilgileri varsa, bunların giderilmesi amaçlanmıştır. Öğrencilerin ortak cevaplarda uzlaşmalarından sonra; öğretmen konuyu toparlar. Asit ve bazların genel özelliklerini öğrencilere özetler. Bu kısımda öğretmen isterse, öğrencileri de katarak kavramsal özet yapabilir.

Etkinlikten Sonra Yapılacaklar:

Tüm sınıf her soru için ortak bir fikirde uzlaştıktan sonra; etkinlikten önce ne biliyordu, etkinlik sonunda ne öğrendiler, değişen fikirleri oldu mu gibi sorulara ait cevaplarını yazılı olarak çalışma yapraklarına kaydederler.

Bunlara ek olarak öğrencilerin asit ve bazların genel özellikleri ile ilgili sahip oldukları kavram yanılgılarının öğrencilerinde olup olmadığının özenle incelenmesi gerekmektedir.

Son olarak çalışma yapraklarında geçen hikâye ile asit ve bazların farklılıklarının vurgulanması gerekmektedir. Böylece, öğrencilerin kafasında oluşabilecek herhangi bir kavram yanılgısından kaçınılmış olunacaktır. Örneğin;

- Asit ve bazlar canlı değillerdir. Bu sebeple, düşünme yeteneklerinin olması beklenemez.

- Asit ve bazlar canlı olmadıkları için; güçlü/kuvvetli asit ve bazlar için kol gücünden bahsedilemez.
- Asit ve bazlar canlı olmadıkları için yorulmazlar, terlemezler, birbirleriyle karate yapmazlar vs.

ETKİNLİK SONRASINDA VURGULANACAK KAVRAM YANILGILARI

- Asitlerin/ bazların kuvvetli yada zayıf olması asidik özelliklerini etkiler.
- Asitler her türlü şeyi yakar ve eritirler.
- Asitler metallleri eritirler.
- Asit ve bazlar içine atılan metali eritip yok ederler.
- Asitler kesinlikle yakıcı ve delici değildir. Tüm asitler zararsızdır.
- Asitler turnusol kâğıdını maviye çevirir.
- Bazlar turnusol kâğıdını kırmızıya çevirir.
- Asitlere elektriği iletirler. Bazlarsa iletmezler.
- Bazlar elektriği iletirler. Asitlerse iletmezler.
- Tüm asitler yakıcıdır.
- Asitler acıdır /tatlıdır / tatsızdır / tadı yoktur
- Bazlar ekşidir / tatlıdır / tatsızdır / tadı yoktur.
- Bir madde yakıcı özellikte ise o madde kesinlikle asittir.
- Tüm asitler kuvvetlidir. O nedenle canımızı yakarlar.
- Bazlar yakıcı özelliğe sahip olduğu için bunlara dokunduğumuzda acı hissederiz.
- Tüm asitler ve bazlar zararsız maddelerdir. Hepsi tadılabilir ve dokunulabilirdir.
- Asitler zararsızdır. Dolayısıyla asit yağmurları tarihi eserler üzerinde hiçbir etki yapmazlar.
- Tüm bazlar zararsızdır.
- Asit/baz çözeltileri elektrik akımını iletmez.

APPENDIX J

EXAMPLES OF STUDENTS' RESPONSES TO REFLECTION PAPERS

KARATE KIDS MATERYALİ DEĞERLENDİRME FORMU

Bu materyal ile öğrendim/fark ettim ki...

Asitler ve bazların birkaç özelliği karate ve ben bunların birçoğunu kafamda belirledim ve artık bunların özelliklerini çok iyi biliyorum. Ayrıca kuvvetli veya zayıf asit ve bazları karşılaştırmayı öğrendim. Kuvvetlilik ve zayıflığın pH ile ilgili değil, suda olan iyonlaşıp iyonlaşmamasıyla ilgili olduğunu öğrendim ve fark ettim ki farkında olmadan bile birçok kuvvetli ve zayıf baz örneği öğrenmişim

Bu materyalde eksik buldum, ... hakkında bilgi olmasını beklerdim.

Bu materyalde eksik buldum. Günlük yaşamda asitler ve bazların genel özelliklerine daha çok yer verilebilirdi. Ayrıca kuvvetli asit ve bazları daha iyi tanımamızı sağlayan etkinliklere de yer verilebilirdi. Ayrıca günlük hayatta karşılaştığımız asit, baz çeşitlerinin ve bunların özelliklerinin hakkında bilgi olmasını beklerdim

KARATE KIDS MATERYALİ DEĞERLENDİRME FORMU

Bu materyal ile öğrendim/fark ettim ki...

Bazı asit ve bazların zayıflık-kuvvetlilik durumunu karıştırdığımı farkettim.

Bu materyalde eksik buldum, ... hakkında bilgi olmasını beklerdim.

asit ve bazlardan genel olarak bahsetmek için yeterli bir materyaldi.

KARATE KIDS MATERYALİ DEĞERLENDİRME FORMU

Bu materyal ile öğrendim/fark ettim ki...

Asit ve bazlar ile günlük hayat arasında bağlantı kurulabiliyormuş. Asit ve bazlar konusunu pekiştirmiş oldum.

Bu materyalde eksik buldum, ... hakkında bilgi olmasını beklerdim.

Eksik bulduğum bir konu yok

GÜNLÜK HAYATIMIZDA YER ALAN ASİTLER VE BAZLAR MATERYALİ DEĞERLENDİRME FORMU

Bu materyal ile öğrendim/fark ettim ki...

Bazı sebze ve meyveler asidik ve bazik özellikte olabilirler.
Tüm katkı maddeleri insan sağlığına zararlı değildir.

Bu materyalde eksik buldum, ... hakkında bilgi olmasını beklerdim.

Eksik bulmadım.

GÜNLÜK HAYATIMIZDA YER ALAN ASİTLER VE BAZLAR MATERYALİ DEĞERLENDİRME FORMU

Bu materyal ile öğrendim/fark ettim ki...

Yediğimiz besinlerinlerin, kullandığımız malzemelerin hemen hemen çoğunda asit ve bazların bulunduğu ve hepsinin faydalı olmadığı gibi yine hepside zararlı değil. Tahriş edenide, faydalı olanıda var. Kısaca asit / bazlar hayatımızın her yerinde. Bazı asitler vücutta kanı bazik, bazı bazlarda kanı asidik yapıyor.

Bu materyalde eksik buldum, ... hakkında bilgi olmasını beklerdim.

Bu materyalde asit / bazların bulunduğu gıdalar; hatta kanı çevirdikleri bulunuyor fakat tahriş edenler, besin maddeleri dışında bulunanlar eksikti.

BİTKİLER VE TUZLAR MATERYALİ DEĞERLENDİRME FORMU

Bu materyal ile öğrendim/fark ettim ki…

Çeşitli bitkilerin pH aralığı, tampon çözeltiler. Konjuge asit-baz çiftleri. Tuz çeşitleri. Asidik, bazik ve nötral tuzlar neye göre oluşur Bunları öğrendim.

Bu materyalde eksik buldum, …….. hakkında bilgi olmasını beklerdim.

Materyal tam bilgilendirdi. Herhangi bir eksik veya fazlalık yoktu.

BİTKİLER VE TUZLAR MATERYALİ DEĞERLENDİRME FORMU

Bu materyal ile öğrendim/fark ettim ki…

Asit ve bazların kuvvetli mi zayıf olduklarını iyice öğrendim. Daha önce bile duymadığım bazı bitkilerin bağ [illegible] daha iyi yaşayacağını asit ve bazlar konusunda [illegible] daha iyi kavradım.

Bu materyalde eksik buldum, …….. hakkında bilgi olmasını beklerdim.

Bitkilerin yetiştirildiği toprak türleri hakkında daha fazla bilgi vermesini isterdim. Ayrıca asit-bazların kuvvetlilerinin nasıl olacağını açıklamasını isterdim.

APPENDIX K

EXAMPLES OF STUDENTS' RESPONSES TO QUESTIONS IN CASES

SORULAR:

1. 8. sınıftaki bilgilerinizden yararlanarak siz çalışma yaprağında okuduklarınızla kimyanın "Asitler ve bazların genel özellikleri" konusunu nasıl ilişkilendirirdiniz? Neden?

Demir yumruğu baz, kırmızı kediyi asit olarak düşünelim
Demir yumruğun vuruşları morartıcı etki yapar çünkü bazlar turnusol kağıdını maviye çevirir, kırmızı kedi kızartıcı etki yapar çünkü asitler turnusol kağıdını kırmızıya çevirir. Demir yumruk negatif, kırmızı kedi pozitiftir çünkü asitler "+", bazlar "–" yüklüdür.
Asitlerin tadı ekşidir, bazların ise acıdır ve ele kayganlık hissi verir. Asitlerle bazlar tepkimeye sokulursa ortamda tuz ve su oluşur.

2. Sizce parçanın sonunda kırmızı kedi niçin felsefesini değiştiriyor? Bu durum kimyanın asit-baz teorilerinde olabilir mi? Neden?

Arrheniusun tanımı yetersiz kaldığı için

3. Sizce bir asit/baza ne zaman kuvvetli ya da zayıf denir?

Suda çözündüklerinde %100 iyonlaştığı varsayılan asit-baz kuvvetlidir.
Suda çözündüklerinde az iyonlaşan asit-baz ise zayıftır.

4. Lütfen daha önceki bilgilerinizi kullanarak, aklınıza gelen 3 adet asit ve 3 adet baz örneği veriniz.

Asit	Baz
1. HCL	1. LiOH
2. HBr	2. NaOH
3. HI	3. KOH

a. Bu asitlerden hangisi/hangileri kuvvetli asittir? Neden? (Atom no: CL:17, Br:35, I:53)
HI > HBr > HCL Aynı grupta yukarıdan aşağıya doğru atom yarıçapı artar. Buna bağlı olarak asitlik kuvvetide artar. (Bazı elementlerin H ile yaptığı bileşikler asittir.)

b. Bu bazlardan hangileri kuvvetli bazdır? Neden?
KOH > NaOH > LiOH (Atom no: Li:3, Na:11, K:19)
Aynı grupta yukarıdan aşağıya doğru gidildikçe baz özelliği artar.

c. Sizce asit/bazların kuvvetli ya da zayıf olması genel özelliklerini etkiler mi? Neden?
Evet etkiler çünkü kuvvetli asit ve bazların, asitlik ve bazlık sabitleri (K_A ve K_B) çok büyüktür. Zayıf asit ve bazların K_A ve K_B'leri çok küçüktür.

5. Asitler ve/veya bazların buradaki örnekte belirtilmeyen başka genel özellikleri var mıdır? Varsa bunlar nelerdir? Evet vardır.

Sulu çözeltilerinde H^+ iyonu verebilen maddeler asit, OH^- iyonu verebilen maddeler ise bazdır.
Asitlerin pH'ı 0-7, bazlarınki ise 7-14 arasındadır.

SORULAR:

1. 8. sınıftaki bilgilerinizden yararlanarak siz çalışma yaprağında okuduklarınızla kimyanın "Asitler ve bazların genel özellikleri" konusunu nasıl ilişkilendirirdiniz? Neden?

Demir yumruk her vuruşunda morartıcı etki yapıyor, yani bazlar turnusol kağıdını mavi-mor renge çeviriyor. Kırmızı kedi ise kızartıyor yani turnusol kağıdını kırmızıya çeviriyor. Bazlar acı ve kaygan olmasının yanında; asitler ekşidir. Yani bu metinde Demir Yumruk baz; Kırmızı Kedi asit. Mesela birbirleriyle dövüşe çıktıklarında beraber kalmaları, bunun yanında tuz ve su çıkartmalarında "nötralleşmeyi" simgeliyor.

2. Sizce parçanın sonunda kımızı kedi niçin felsefesini değiştiriyor? Bu durum kimyanın asit-baz teorilerinde olabilir mi? Neden?

- Asit ya da Bazlar aynı ortak özelliğe sahip olabilirler. Yani bir asitinde sulu çözeltisi elektriği iletir, bir bazın sulu çözeltiside iletir.

3. Sizce bir asit/baza ne zaman kuvvetli ya da zayıf denir?

Asitin/bazın suda iyonlaşmalarına göre denir. Eğer bir asit/baz suda iyi iyonlaşıyorsa kuvvetlidir.

4. Lütfen daha önceki bilgilerinizi kullanarak, aklınıza gelen 3 adet asit ve 3 adet baz örneği veriniz.

Asit	Baz
1. H_2SO_4 (Sülfürik Asit)	1. NaOH
2. HCN (Hidrosiyanik ")	2. NH_3 (Amonyak)
3. HCl (Hidroklorik ")	3. KOH

a. Bu asitlerden hangisi/hangileri kuvvetli asittir? Neden?

H_2SO_4 ve HCl kuvvetli asit. Çünkü suda iyi iyonlaşırlar.

b. Bu bazlardan hangileri kuvvetli bazdır? Neden?

KOH kuvvetli baz. Çünkü suda iyi iyonlaşır.

c. Sizce asit/bazların kuvvetli ya da zayıf olması genel özelliklerini etkiler mi? Neden?

- Etkiler. Çünkü zayıf olanlar suda az iyonlaşır bu elektriği az iletmesine neden olur.

5. Asitler ve/veya bazların buradaki örnekte belirtilmeyen başka genel özellikleri var mıdır? Varsa bunlar nelerdir?

- Asit ve bazlar suda çözündüklerinde iyon oluşturdukları için çözeltileri elektrolittir.

- Asitler suda çözündüğünde ortama H^+ iyonu, bazlar ise OH^- iyonu verirler.

SORULAR:

1. 8. sınıftaki bilgilerinizden yararlanarak siz çalışma yaprağında okuduklarınızla kimyanın "Asitler ve bazların genel özellikleri" konusunu nasıl ilişkilendirirdiniz? Neden?

Kırmızı kediyi aside, demir yumruğu baza benzettim. Kırmızı kedi insanlara pozitif düşünce ve duygularını aşılamaya çalışıyor, asitlerin suya H^+ iyonu vermesi gibi. İnsanlar "haberiniz olsun şu anda tadı çok ekşi" diyorlar, asitlerin de tadı ekşidir. Demir yumruk ise negatif düşünceler içerisinde, bazlardaki OH^- gibi. İnsanlar "bugün yine tadı çok acı ve kendisi de çok kaygan" diyorlar, bazların tadı acıdır ve ele kayganlık hissi verir.

Kırmızı kedi ve demir yumruk birbirleriyle karate yaptıklarında tuz ve su atıyorlar, asit-baz tepkimeleri sonucunda oluşan tuz ve su gibi.

2. Sizce parçanın sonunda kımızı kedi niçin felsefesini değiştiriyor? Bu durum kimyanın asit-baz teorilerinde olabilir mi? Neden?

Bir su ne kadar asidik olursa olsun içinde mutlaka OH^- iyonu vardır. Aynı şekilde bir su ne kadar bazik olursa olsun içinde mutlaka H^+ iyonu vardır. Buna benzettim.

3. Sizce bir asit/baza ne zaman kuvvetli ya da zayıf denir?

Suda %100'e yakın iyonlaşanlara kuvvetli asit/baz, suda az miktarda iyonlaşanlara zayıf asit/baz denir.

4. Lütfen daha önceki bilgilerinizi kullanarak, aklınıza gelen 3 adet asit ve 3 adet baz örneği veriniz.

Asit	Baz
1. CH_3COOH	1. NH_3
2. HCl	2. NaOH
3. HF	3. $Ca(OH)_2$

a. Bu asitlerden hangisi/hangileri kuvvetli asittir? Neden?

HCl kuvvetli asittir. Çünkü suda %100 iyonlaşır ve tepkimesi şu şekilde tek yönlü okla gösterilir:

$$HCl_{(suda)} \rightarrow H^+_{(suda)} + Cl^-_{(suda)}$$

b. Bu bazlardan hangileri kuvvetli bazdır? Neden?

NaOH ve $Ca(OH)_2$ kuvvetli bazdır. Çünkü suda %100 iyonlaşırlar ve tepkimeleri yine tek okla gösterilir.

$$NaOH_{(suda)} \rightarrow Na^+_{(suda)} + OH^-_{(suda)} \qquad Ca(OH)_{2(suda)} \rightarrow Ca^{+2}_{(suda)} + 2OH^-_{(suda)}$$

c. Sizce asit/bazların kuvvetli ya da zayıf olması genel özelliklerini etkiler mi? Neden?

Etkiler. Örneğin kuvvetli asit/bazların elektrik iletkenlikleri yüksektir. Bu nedenle kuvvetli elektrolittirler.

5. Asitler ve/veya bazların buradaki örnekte belirtilmeyen başka genel özellikleri var mıdır? Varsa bunlar nelerdir?

Vardır. Asitlerin ve bazların sulu çözeltileri iletken özellik gösterir. Asitler aktif metallerle tepkimeye girerek tuz ve $H_{2(g)}$ oluşturur, bazlar amfoter metallerle etkileşerek tuz ve H_2 gazı oluşturur.

SORULAR:

1. Yukarıdaki metne ve daha önceki bilgilerinize göre aşağıdaki soruları **kendi yorumunuzu da katarak** cevaplayabilir misiniz?

a. Sizce asitler yararlı mıdır, zararlı mıdır yoksa her ikisi de olabilir mi? Nedenini bir örnekle açıklayınız. Bence her ikisi de olabilir. Mesela E-330 sitrik asit en tehlikeli kanserojen etki maddesiyken, elmada bulunan malik asit elmaya ekşi tadını verir.

b. Sizce meyveler/sebzeler asidik olabilir mi? Nedenini bir örnekle açıklayınız.

Evet olabilir. Örneğin; elmada malik asit vardır, yani asidiktir. Mısır, mercimek ve zeytin sebzedir ve asidiktir. Limon, karpuz, kavun, greyfurt, kabak turşu gibi meyve sebzeler asidiktir.

c. Sizce tüm asitler yenilebilir mi? Nedenini bir örnekle açıklayınız.

Hayır tüm asitler yenilemez. Çünkü çok kuvvetli asitler insan sağlığına zarar verir. Örneğin florosülfürik ~~asit~~ içinde bulunan kabı dahi eritebilecek güçtedir.

2. **Yukarıda asitler için cevapladığınız üç şıkkı, kendi yorumunuz doğrultusunda bazlar hakkında da cevaplayabilir misiniz?**

a. Sizce bazlar yararlı mıdır, zararlı mıdır yoksa her ikisi de olabilir mi? Nedenini bir örnekle açıklayınız. Her ikisi de olabilir. Mesela balıkların pullarında, memelilerin karaciğer ve pankreasında bulunan bazlar yararlıdır. Kuvvetli bazlardan olan NaOH, KOH, $Sr(OH)_2$, $Ba(OH)_2$ zararlıdır.

b. Sizce meyveler/sebzeler bazik olabilir mi? Nedenini bir örnekle açıklayınız.

Evet olabilir. Örneğin; muz, hurma, ıspanak, sarımsak patates, mısır gibi sebze meyveler baziktir.

c. Sizce tüm bazlar yenilebilir mi? Nedenini bir örnekle açıklayınız.

Hayır tüm bazlar yenilemez.
Mesela NH_3 (amonyak) yemenizi önermiyorum.
Ya da kuvvetli bazlar olan NaOH, KOH, $Ba(OH)_2$ sağlığımıza zarar verir.

3. **Sizce tüm asitler için, katkı maddeleri olarak kullanıldığında "insan sağlığına zararlıdır" denilebilir mi? Neden?** Hayır denilemez. Farklı görevleri ya da kullanım alanları olan kimisi doğada var olurken kimisi sadece sentezlenen ve gıdalarımızda yer alan bir çok farklı asit vardır. Bunların bir kısmı doğal haliyle veya suni yollarla üretilerek koruyucu katkı maddesi olarak kullanılmaktadır. Bu sebeple tüm katkı maddeleri insan sağlığına zararlıdır denilemez.

SORULAR:

1. Yukarıdaki metne ve daha önceki bilgilerinize göre aşağıdaki soruları **kendi yorumunuzu da katarak** cevaplayabilir misiniz?

   a. Sizce asitler yararlı mıdır, zararlı mıdır yoksa her ikisi de olabilir mi? Nedenini bir örnekle açıklayınız.

   Her ikisi de. Eğer doğal yollarla olanını alırsak, örneğin bir portakal yersek bu yararlıdır ve doğal olarak sitrik asit almış oluruz. Ama hazır çorba içersek yine sitrik asit almış oluruz fakat bu kanser bile yapabilecek kadar zararlıdır.

   b. Sizce meyveler/sebzeler asidik olabilir mi? Nedenini bir örnekle açıklayınız.

   Olabilir. Yeşil, ekşi bir elmanın asidik olduğunu tadının ekşiliğinden anlayabiliriz. Kabuğunu soyduğumuzda küçük küçük kabarcıklar oluşuyor, bu da asidik olduğunu gösterir.

   c. Sizce tüm asitler yenilebilir mi? Nedenini bir örnekle açıklayınız.

   Yenilemez. Örneğin HNO_3 (nitrik asit), halk dilinde kezzap olarak bilinir ve yemek/içmek bir yana, elimizi bile süremeyiz.

2. Yukarıda asitler için cevapladığınız üç şıkkı, **kendi yorumunuz doğrultusunda** bazlar hakkında da cevaplayabilir misiniz?

   a. Sizce bazlar yararlı mıdır, zararlı mıdır yoksa her ikisi de olabilir mi? Nedenini bir örnekle açıklayınız.

   Her ikisi de. Limon en yüksek alkali etkiye sahip gıdalardan biri ve bu yararlıdır. Ama hazır gıdaları tüketirsek zararlı olabilir.

   b. Sizce meyveler/sebzeler bazik olabilir mi? Nedenini bir örnekle açıklayınız.

   Olabilir. Limon, tüketilmeden önce asidik değere sahip olsa da, sindirim sonrasında bazik etki yapıyor.

   c. Sizce tüm bazlar yenilebilir mi? Nedenini bir örnekle açıklayınız.

   Yenilemez. Örneğin sönmüş kireç olarak bildiğimiz $Ca(OH)_2$ yenmez.

3. Sizce tüm asitler için, katkı maddeleri olarak kullanıldığında "insan sağlığına zararlıdır" denilebilir mi? Neden?

   Hayır. Eğer doğal haliyle üretilirse zararlı olmaz.

SORULAR:

1. Yukarıdaki metne ve daha önceki bilgilerinize göre aşağıdaki soruları **kendi yorumunuzu da katarak** cevaplayabilir misiniz?

   a. Sizce asitler yararlı mıdır, zararlı mıdır yoksa her ikisi de olabilir mi? Nedenini bir örnekle açıklayınız.

   Her ikisi de olabilir. Örnek: Benzoik asit → kaşıntı, sinirsel bozukluk ve çocuklarda hiperaktiviteye [illegible]. Sitrik asit: Her gün içtiğimiz kola, meyve ve kasaplardaki [illegible] yer alabilir (zararlı). Gemisi [illegible] sularında kullanılır ← HCl, H_2SO_4 ⟶ Koruyucu katkı maddesi

   b. Sizce meyveler/sebzeler asidik olabilir mi? Nedenini bir örnekle açıklayınız. örnek [illegible]

   Olabilir. Örnek: limon bir sebzedir, domates bir meyvedir. Bunlar asidiktir. Elma, çilek bir meyvedir. Bunlar da asidiktir.

   c. Sizce tüm asitler yenilebilir mi? Nedenini bir örnekle açıklayınız.

   Yenilemez. Örnek: formik asit karınca asidi olarak da bilinir. Çeşitli sanayi dallarında kullanılır ama gıda sanayinde kullanılması doğal olmadığı için yenilenemez.

2. Yukarıda asitler için cevapladığınız üç şıkkı, **kendi yorumunuz doğrultusunda** bazlar hakkında da cevaplayabilir misiniz?

   a. Sizce bazlar yararlı mıdır, zararlı mıdır yoksa her ikisi de olabilir mi? Nedenini bir örnekle açıklayınız. Bazlar da yararlı ya da zararlı olabilir. Örneğin; sabun yararlıdır (Elimizi yıkamak için kullanırız). NH_3 (amonyak) da bir bazdır ama zehirli bir kimyasal olarak kullanılır. Bu nedenle de sağlığa zararlıdır.

   NaOH vücudu tahriş eder (zararlıdır)

   b. Sizce meyveler/sebzeler bazik olabilir mi? Nedenini bir örnekle açıklayınız.

   Olabilir. Bence biber ve zerdeçal baziktir. Çünkü tadları acıdır. Ekşimtrak tadları yoktur. Muz da bazik olabilir, çünkü muz yiyince ağzımızda kayganlık hissi oluşur. Ağızda asidik özellik bu sebzelerde görülmüyor.

   c. Sizce tüm bazlar yenilebilir mi? Nedenini bir örnekle açıklayınız.

   Yenilemez. Örnek: NH_3 yenilemez. Çünkü zararlı bir kimyasaldır. Sabun yenilemez.

3. Sizce tüm asitler için, katkı maddeleri olarak kullanıldığında "insan sağlığına zararlıdır" denilebilir mi? Neden? Hayır. Çünkü bazı katkı maddeleri koruyucu olarak da kullanılır. Örneğin; her gün asitli içecekler içiyoruz ve tabiki onların içinde zararlı katkı maddeleri var ama bazıları da onların ömrünün uzamasını sağlıyor. Bunun gibi de örnek verebiliriz. İçinde [illegible] asit var ve tükettiğimiz şeylerdeki katkı maddeleri onların çabuk bozulmasını engelliyor. Ya da HCl, H_2SO_4, HCl gibi asitler sanayi dallarında kullanılırlar ve hayatımızı kolaylaştırırlar. Bunun gibi birçok örnek verilebilir.

4. Aşağıdaki tabloyu yukarıdaki bilgiler ve cevaplarınız doğrultusunda doldurunuz:

	Doğru	Yanlış	Bilmiyorum
Meyvelerin tadında asitliğin ve/veya bazlığın etkisi vardır.	✓		
Tüm asit ve bazlara dokunulabilir.		✓	
Bazı bazlar ve asitler organiktir. → CH_3COOH $HCOOH$	✓		
Tüm bazlar yararlıdır.		✓	
Tüm katkı maddeleri sağlığa zararlıdır.		✓	
Bazı asitler zehirlidir.	✓		
Asit ve bazların sanayide kullanımı sadece yapay üretim yoluyla olur.		✓	
Sebzeler asidik özellik gösterdiklerinden acımsı tattadırlar.		✓	
Yapay asitlerin bir kısmı insanlara ciddi zararlar verirler.	✓		
Tüm asitler zararsızdır.		✓	
Meyveler bazik özellikte olduklarından ekşi tattadırlar.		✓	
Tüm bazlar zararsızdır.		✓	
Tüm asit ve bazlar yenilebilir.		✓	
Meyvelerin tümü asidik özelliktedirler.		✓	
Tüm asitler yararlıdır.		✓	
Bazı asitler sağlığımıza zararlıdır.	✓		

5. Aşağıda sizler için bir liste verilmiştir. Bu listede, yapılarında asit/baz olan meyve ve sebzelerle; kanımızı asidik ve bazik yapan sebze ve meyvelerden bazıları görünmektedir. Buradaki sebze ve meyvelerin bir kısmı; normalde yapılarında asit olmasına rağmen, kanı bazik yapmakta veya normalde yapılarında baz olmasına rağmen kanı asidik yapmaktadır. Sizce bunun nedeni nedir? Kendi fikirlerinizi birkaç cümle ile açıklayınız.

	Yapılarında Asit Bulunan Sebze ve Meyveler	Yapılarında Baz Bulunan Sebze ve Meyveler
Kanı Bazik Yapan Sebze ve Meyveler	Limon, karpuz, kavun, üzüm, armut, kayısı, havuç, portakal, şeftali, çilek, soğan, domates, susam tohumu, patlıcan, greyfurt, mandalina, kivi, ananas, incir, kabak, elma, kuş üzümü, turşu	Muz, hurma, sarımsak, ıspanak, taze fasulye, brokoli, lahana, biber, patates, mısır, badem, salatalık, Karaturp, pazı, nane, zerdeçal, badem, marul
Kanı Asidik Yapan Sebze ve Meyveler	Un, buğday, şeker, pirinç, erik, yabanmersini, ceviz, ekmek, margarin, mayonez, ketçap, ceviz, fındık, nar, yeşil zeytin, kahve, çikolata, peynir	Yumurta, kırmızı et, beyaz et, balık, olgun zeytin

Bence vücudumuz bir etki-tepki mekanizması olarak hareket etmektedir. Bu yüzden vücudumuzda asidik madde bazik, bazik madde asidik özellik göstermektedir. Daha açık bir şekilde söyleyecek olursak vücudumuz bir tampon mekanizması gibi hareket etmektedir. Asit eklediğimiz zaman vücudumuz kan pH'ı korumak istiyor ve zayıf asidin tuzu olan bazik tuz harekete geçiyor. Bu da kanı bazik yapıyor. Aynı şey zayıf baz için de geçerlidir. Bunlar vücudun kendi koruma mekanizmasının bir örneğidir.

4. Aşağıdaki tabloyu yukarıdaki bilgiler ve cevaplarınız doğrultusunda doldurunuz:

	Doğru	Yanlış	Bilmiyorum
Meyvelerin tadında asitliğin ve/veya bazlığın etkisi vardır.	X ✓		
Tüm asit ve bazlara dokunulabilir.		X ✓	
Bazı bazlar ve asitler organiktir.	(✓)	X	
Tüm bazlar yararlıdır.		X ✓	
Tüm katkı maddeleri sağlığa zararlıdır.		X ✓	
Bazı asitler zehirlidir.	(✓)	X	
Asit ve bazların sanayide kullanımı sadece yapay üretim yoluyla olur.		X ✓	
Sebzeler asidik özellik gösterdiklerinden acımsı tattadırlar.		X ✓	
Yapay asitlerin bir kısmı insanlara ciddi zararlar verirler.	X ✓		
Tüm asitler zararsızdır.		X	
Meyveler bazik özellikte olduklarından ekşi tattadırlar.		X	
Tüm bazlar zararsızdır.		X	
Tüm asit ve bazlar yenilebilir.		X	
Meyvelerin tümü asidik özelliktedirler.		X	
Tüm asitler yararlıdır.		X	
Bazı asitler sağlığımıza zararlıdır.	X		

5. Aşağıda sizler için bir liste verilmiştir. Bu listede, yapılarında asit/baz olan meyve ve sebzelerle; kanımızı asidik ve bazik yapan sebze ve meyvelerden bazıları görünmektedir. Buradaki sebze ve meyvelerin bir kısmı; normalde yapılarında asit olmasına rağmen, kanı bazik yapmakta veya normalde yapılarında baz olmasına rağmen kanı asidik yapmaktadır. Sizce bunun nedeni nedir? Kendi fikirlerinizi birkaç cümle ile açıklayınız.

	Yapılarında Asit Bulunan Sebze ve Meyveler	Yapılarında Baz Bulunan Sebze ve Meyveler
Kanı Bazik Yapan Sebze ve Meyveler	Limon, karpuz, kavun, üzüm, armut, kayısı, havuç, portakal, şeftali, çilek, soğan, domates, susam tohumu, patlıcan, greyfurt, mandalina, kivi, ananas, incir, kabak, elma, kuş üzümü, turşu	Muz, hurma, sarımsak, ıspanak, taze fasulye, brokoli, lahana, biber, patates, mısır, badem, salatalık, Karaturp, pazı, nane, zerdeçal, badem, marul
Kanı Asidik Yapan Sebze ve Meyveler	Un, buğday, şeker, pirinç, erik, yabanmersini, ceviz, ekmek, margarin, mayonez, ketçap, ceviz, fındık, nar, yeşil zeytin, kahve, çikolata, peynir	Yumurta, kırmızı et, beyaz et, balık, olgun zeytin

Yapılarında bulunan asit-baz zayıfsa kana bu özelliklerini yansıtamıyor olabilirler. Zayıf baz sindirimde kuvvetli bir asitle karşılaşıp baz özelliğini gösteremiyor olabilir.

SORULAR:

1. Yukarıda size verilen "toprakta bulunan toprakta bulunan çeşitli tuz çözeltileri ve bunların oluşumları tablosunda" (Tablo 1) ne tip asit ve bazların, verilen tuzların oluşumunu sağladığını göz önünde bulundurarak; aşağıda verilen tuzların karakterlerini (asidik, bazik, nötr) belirleyiniz.

Çeşitli Tuz Çözeltileri	Kuvvetli Asit + Kuvvetli Baz	Zayıf Asit + Kuvvetli Baz	Zayıf Baz + Kuvvetli Asit	Zayıf Asit + Zayıf Baz	Tuzun Karakteri
NH_4Cl			X		asidik
CH_3COONa		X			bazik
$FeCl_3$			X		asidik
$CuSO_4$			X		asidik
NaCN		X			bazik
KNO_3	X				nötr
KNO_2		X			bazik
$Al(NO_3)_3$			X		asidik
$MgCO_3$				X	K_a, K_b bakılır.
$MnCl_2$			X		asidik
$Al(OH)_2Cl$			X		asidik
$CaSO_4$			X		asidik
$ZnCl_2$			X		asidik
K_3PO_4		X			bazik

2. Yukarıdaki bilgiler ışığında, her bir bitkinin Tablo 1'de verilen tuzların içerisinden hangi besin tuzlarına kolaylıkla ulaşabileceği ve ulaşamayacağını belirleyerek aşağıdaki tabloya yazınız.

Bitki	Ulaşabileceği Tuzlar	Ulaşamayacağı tuzlar
Maviyemiş	Asidik	Bazik
Çanta Çiçeği	Asidik	Bazik
Kalp Kalbe Karşı	Nötr - Asidik	Bazik
Leylak	Nötr - Bazik	Asidik
Kauçuk	Nötr - Bazik	Asidik
Kanarya otu	Bazik	Asidik

a. Neden bu şekilde düşündüğünüzü lütfen açıklayınız.

Her bitki kendi sevdiği pH'ta yaşıyorsa, bazik toprak seven bitkinin toprağında asit tuz olmaz.

SORULAR:

1. Yukarıda size verilen "toprakta bulunan toprakta bulunan çeşitli tuz çözeltileri ve bunların oluşumları tablosunda" (Tablo 1) ne tip asit ve bazların, verilen tuzların oluşumunu sağladığını göz önünde bulundurarak; aşağıda verilen tuzların karakterlerini (asidik, bazik, nötr) belirleyiniz.

Çeşitli Tuz Çözeltileri	Kuvvetli Asit + Kuvvetli Baz	Zayıf Asit + Kuvvetli Baz	Zayıf Baz + Kuvvetli Asit	Zayıf Asit + Zayıf Baz	Tuzun Karakteri
NH_4Cl			X		asidik
CH_3COONa		X			bazik
$FeCl_3$			X		asidik
$CuSO_4$			X		asidik
NaCN		X			bazik
KNO_3	X				nötr
KNO_2		X			bazik
$Al(NO_3)_3$			X		asidik
$MgCO_3$		X			bazik
$MnCl_2$			X		asidik
$Al(OH)_2Cl$			X		asidik
$CaSO_4$	X				nötr
$ZnCl_2$			X		asidik
K_3PO_4		X			bazik

2. Yukarıdaki bilgiler ışığında, her bir bitkinin Tablo 1'de verilen tuzların içerisinden hangi besin tuzlarına kolaylıkla ulaşabileceği ve ulaşamayacağını belirleyerek aşağıdaki tabloya yazınız.

Bitki	Ulaşabileceği Tuzlar	Ulaşamayacağı tuzlar
Maviyemiş	Asidik tuz NH_4Cl, $FeCl_3$, $CuSO_4$, $Al(NO_3)_3$	Bazik tuz K_3PO_4, $MgCO_3$, NaCN
Çanta Çiçeği	Asidik tuzlar. NH_4Cl, $FeCl_3$, $CuSO_4$	Bazik tuzlar. K_3PO_4, $MgCO_3$, CH_3COONa
Kalp Kalbe Karşı	Nötr tuz KNO_3, $CaSO_4$	Asidik ve bazikler NH_4Cl, CH_3COONa, $FeCl_3$
Leylak	Bazik tuz $MgCO_3$, K_3PO_4, KNO_2	Asidik tuz. $FeCl_3$, $CuSO_4$, $MnCl_2$
Kauçuk	Bazik tuz K_3PO_4, CH_3COONa, KNO_2	Asidik tuz NH_4Cl, $FeCl_3$, $CuSO_4$, $Al(NO_3)_3$
Kanarya otu	Bazik K_3PO_4, CH_3COONa, KNO_2	Asidik NH_4Cl, $FeCl_3$, $CuSO_4$, $Al(NO_3)_3$

a. Neden bu şekilde düşündüğünüzü lütfen açıklayınız.

- Bu bitkilerin bazıları bazik ortamda, bazıları asidik, bazıları nötr ortamda yaşayabiliyor (yetişebiliyor). Bu durumda bazik ortamda yetişen asidik tuzlara yetişemez; asidik ortamdaki bazik tuza ulaşamaz.

SORULAR:

1. Yukarıda size verilen "toprakta bulunan toprakta bulunan çeşitli tuz çözeltileri ve bunların oluşumları tablosunda" (Tablo 1) ne tip asit ve bazların, verilen tuzların oluşumunu sağladığını göz önünde bulundurarak; aşağıda verilen tuzların karakterlerini (asidik, bazik, nötr) belirleyiniz.

Çeşitli Tuz Çözeltileri	Kuvvetli Asit + Kuvvetli Baz	Zayıf Asit + Kuvvetli Baz	Zayıf Baz + Kuvvetli Asit	Zayıf Asit + Zayıf Baz	Tuzun Karakteri
NH_4Cl			✓		Asidik
CH_3COONa		✓			Bazik
$FeCl_3$			✓		Asidik
$CuSO_4$			✓		Asidik
NaCN		✓			Bazik
KNO_3	✓				Nötr
KNO_2		✓			Bazik
$Al(NO_3)_3$			✓		Asidik
$MgCO_3$				✓	(kum ve killere
$MnCl_2$			✓		Asidik
$Al(OH)_2Cl$			✓		Asidik
$CaSO_4$			✓		Asidik
$ZnCl_2$			✓		Asidik
K_3PO_4		✓			Bazik

(bağlanmaz? [illegible])

2. Yukarıdaki bilgiler ışığında, her bir bitkinin Tablo 1'de verilen tuzların içerisinden hangi besin tuzlarına kolaylıkla ulaşabileceği ve ulaşamayacağını belirleyerek aşağıdaki tabloya yazınız.

Bitki	Ulaşabileceği Tuzlar	Ulaşamayacağı tuzlar
Maviyemiş	NH_4Cl, $MnCl_2$, $Al(OH)_2Cl$	Diğerleri
Çanta Çiçeği	NH_4Cl, $MnCl_2$, $Al(OH)_2Cl$	Diğerleri
Kalp Kalbe Karşı	$FeCl_3$, $CuSO_4$, KNO_3, $Al(NO_3)_3$, $ZnCl_2$	Diğerleri
Leylak	Nötr tuzlar	Asidik ve bazik tuzlar
Kauçuk	Nötr ve bazik tuzlar	Asidik tuzlar
Kanarya otu	Nötr ve bazik tuzlar	Asidik tuzlar

a. Neden bu şekilde düşündüğünüzü lütfen açıklayınız.

Çünkü her bitki için ideal pH değeri farklıdır. Bazıları asidik bazıları ise nötr toprağı sevmediğinden böyle bir tablo oluşmuştur

3. Tablo 1'de verilen bu tuzların su ile tepkimelerini gösteren tabloyu doldurunuz.

Çeşitli Tuz Çözeltileri	Tuzun Suda Çözünmesi
NH_4Cl	$NH_4Cl + H_2O \rightarrow NH_4OH + HCl$
CH_3COONa	$CH_3COONa + H_2O \rightarrow CH_3COOH + NaOH$
$FeCl_3$	$FeCl_3 + H_2O \rightarrow 3HCl + Fe(OH)_3$
$CuSO_4$	$CuSO_4 + 2H_2O \rightarrow H_2SO_4 + Cu(OH)_2$
$NaCN$	$NaCN + H_2O \rightarrow NaOH + HCN$
KNO_3	$KNO_3 + H_2O \rightarrow HNO_3 + KOH$
KNO_2	$KNO_2 + H_2O \rightarrow HNO_2 + KOH$
$Al(NO_3)_3$	$Al(NO_3)_3 + 3H_2O \rightarrow Al(OH)_3 + 3HNO_3$
$MgCO_3$	$MgCO_3 + 2H_2O \rightarrow H_2CO_3 + Mg(OH)_2$
$MnCl_2$	$MnCl_2 + 2H_2O \rightarrow Mn(OH)_2 + 2HCl$
$Al(OH)_2Cl$	$Al(OH)_2Cl + H_2O \rightarrow Al(OH)_3 + HCl$
$CaSO_4$	$CaSO_4 + 2H_2O \rightarrow H_2SO_4 + Ca(OH)_2$
$ZnCl_2$	$ZnCl_2 + 2H_2O \rightarrow Zn(OH)_2 + 2HCl$
K_3PO_4	$K_3PO_4 + H_2O \rightarrow KOH + H_3PO_4$

4. Tablo 1'de verilen bu tuzların kendisi, katyon ve anyonları ile bunların karakterlerini gösteren tabloyu doldurarak birinci sorudaki cevabınız ile karşılaştırınız.

Çeşitli Tuz Çözeltileri	Katyonun karakteri	Anyonun Karakteri	Tuzun Karakteri
NH_4Cl	Zayıf	Kuvvetli	Asidik
CH_3COONa	Kuvvetli	Zayıf	Bazik
$FeCl_3$	Zayıf	Kuvvetli	Asidik
$CuSO_4$	Zayıf	Kuvvetli	Asidik
$NaCN$	Kuvvetli	Zayıf	Bazik
KNO_3	Kuvvetli	Kuvvetli	Nötr
KNO_2	Kuvvetli	Zayıf	Bazik
$Al(NO_3)_3$	Zayıf	Kuvvetli	Asidik
$MgCO_3$	Zayıf	Zayıf	Ka ve Kb'ye bakılır
$MnCl_2$	Zayıf	Kuvvetli	Asidik
$Al(OH)_2Cl$	Zayıf	Kuvvetli	Asidik
$CaSO_4$	Zayıf	Kuvvetli	Asidik
$ZnCl_2$	Zayıf	Kuvvetli	Asidik
K_3PO_4	Kuvvetli	Zayıf	Bazik

a. İki tablo arasında tuzun karakteri açısından bir fark oldu mu? Sizce neden?

Olmadı. Çünkü ikisinde de asit ve bazın kuvvetli mi zayıf mı olduğuna baktık.

3. Tablo 1'de verilen bu tuzların su ile tepkimelerini gösteren tabloyu doldurunuz.

Çeşitli Tuz Çözeltileri	Tuzun Suda Çözünmesi
NH_4Cl	$NH_4Cl_{(suda)} \longrightarrow NH_4^+{}_{(suda)} + Cl^-{}_{(suda)}$
CH_3COONa	$CH_3COONa_{(suda)} \longrightarrow CH_3COO^-{}_{(suda)} + Na^+{}_{(suda)}$
$FeCl_3$	$FeCl_{3(suda)} \longrightarrow Fe^{+3}{}_{(suda)} + 3Cl^-{}_{(suda)}$
$CuSO_4$	$CuSO_{4(suda)} \longrightarrow Cu^{+2}{}_{(suda)} + SO_4^{-2}{}_{(suda)}$
$NaCN$	$NaCN_{(suda)} \longrightarrow Na^+{}_{(suda)} + CN^-{}_{(suda)}$
KNO_3	$KNO_{3(suda)} \longrightarrow K^+{}_{(suda)} + NO_3^-{}_{(suda)}$
KNO_2	$KNO_{2(suda)} \longrightarrow K^+{}_{(suda)} + NO_2^-{}_{(suda)}$
$Al(NO_3)_3$	$Al(NO_3)_{3(suda)} \longrightarrow Al^{+3}{}_{(suda)} + 3NO_3^-{}_{(suda)}$
$MgCO_3$	$MgCO_{3(suda)} \longrightarrow Mg^{+2}{}_{(suda)} + CO_3^{-2}{}_{(suda)}$
$MnCl_2$	$MnCl_{2(suda)} \longrightarrow Mn^{+2}{}_{(suda)} + 2Cl^-{}_{(suda)}$
$Al(OH)_2Cl$	$Al(OH)_2Cl_{(suda)} \longrightarrow Al(OH)_2^+{}_{(suda)} + Cl^-{}_{(suda)}$
$CaSO_4$	$CaSO_{4(suda)} \longrightarrow Ca^{+2}{}_{(suda)} + SO_4^{-2}{}_{(suda)}$
$ZnCl_2$	$ZnCl_{2(suda)} \longrightarrow Zn^{+2}{}_{(suda)} + 2Cl^-{}_{(suda)}$
K_3PO_4	$K_3PO_{4(suda)} \longrightarrow 3K^+{}_{(suda)} + PO_4^{-3}{}_{(suda)}$

4. Tablo 1'de verilen bu tuzların kendisi, katyon ve anyonları ile bunların karakterlerini gösteren tabloyu doldurarak birinci sorudaki cevabınız ile karşılaştırınız.

Çeşitli Tuz Çözeltileri	Katyonun karakteri	Anyonun Karakteri	Tuzun Karakteri
NH_4Cl	Zayıf	Kuvvetli	Asidik
CH_3COONa	Kuvvetli	Zayıf	Bazik
$FeCl_3$	Zayıf	Kuvvetli	Asidik
$CuSO_4$	Zayıf	Kuvvetli	Asidik
$NaCN$	Kuvvetli	Zayıf	Bazik
KNO_3	Kuvvetli	Kuvvetli	Nötr
KNO_2	Kuvvetli	Zayıf	Bazik
$Al(NO_3)_3$	Zayıf	Kuvvetli	Asidik
$MgCO_3$	Zayıf	Zayıf	K_a, K_b bağlı
$MnCl_2$	Zayıf	Kuvvetli	Asidik
$Al(OH)_2Cl$	Zayıf	Kuvvetli	Asidik
$CaSO_4$	Zayıf	Kuvvetli	Asidik
$ZnCl_2$	Zayıf	Kuvvetli	Asidik
K_3PO_4	Kuvvetli	Zayıf	Bazik

a. İki tablo arasında tuzun karakteri açısından bir fark oldu mu? Sizce neden?

Hayır.

5. Tablo 1'de verilen tuzların anyon ve katyonlarının konjuge asit/bazlarını yazınız.

Çeşitli Tuz Çözeltileri	Anyon ve Konjuge Asiti	Katyon ve Konjuge Bazı
NH_4Cl	Cl^- / HCl	NH_4^+ / NH_3
CH_3COONa	CH_3COO^- / CH_3COOH	Na^+ / $NaOH$
$FeCl_3$	Cl^- / HCl	Fe^{+3} / $Fe(OH)_3$
$CuSO_4$	SO_4^{-2} / H_2SO_4	Cu^{+2} / $Cu(OH)_2$
$NaCN$	CN^- / HCN	Na^+ / $NaOH$
KNO_3	NO_3^- / HNO_3	K^+ / KOH
KNO_2	NO_2^- / HNO_2	K^+ / KOH
$Al(NO_3)_3$	NO_3^- / HNO_3	Al^{+3} / $Al(OH)_3$
$MgCO_3$	CO_3^{-2} / H_2CO_3	Mg^{+2} / $Mg(OH)_2$
$MnCl_2$	Cl^- / HCl	Mn^{+2} / $Mn(OH)_2$
$Al(OH)_2Cl$	Cl^- / HCl	$Al(OH)_2^+$ / $Al(OH)_3$
$CaSO_4$	SO_4^{-2} / H_2SO_4	Ca^{+2} / $Ca(OH)_2$
$ZnCl_2$	Cl^- / HCl	Zn^{+2} / $Zn(OH)_2$
K_3PO_4	PO_4^{-3} / H_3PO_4	K^+ / KOH

6. Beşinci soruda belirlediğiniz <u>anyonların konjuge asitlerinin</u> kuvvetli/zayıf olduğunu, doğru olduğunu düşündüğünüz kısma çarpı (X) işaretini koyarak not ediniz.

Çeşitli Tuz Çözeltileri	Anyonun Konjuge Asiti	Kuvvetli Asit	Zayıf Asit
NH_4Cl	HCl	X	
CH_3COONa	CH_3COOH		X
$FeCl_3$	HCl	X	
$CuSO_4$	H_2SO_4	X	
$NaCN$	HCN		X
KNO_3	HNO_3	X	
KNO_2	HNO_2		X
$Al(NO_3)_3$	HNO_3	X	
$MgCO_3$	H_2CO_3		X
$MnCl_2$	HCl	X	
$Al(OH)_2Cl$	HCl	X	
$CaSO_4$	H_2SO_4	X	
$ZnCl_2$	HCl	X	
K_3PO_4	H_3PO_4		X

7. Beşinci soruda belirlediğiniz <u>katyonların konjuge bazlarının</u> kuvvetli/zayıf olduğunu, doğru olduğunu düşündüğünüz kısma çarpı (X) işaretini koyarak not ediniz.

Çeşitli Tuz Çözeltileri	Katyonun Konjuge Bazı	Kuvvetli Baz	Zayıf Baz
NH_4Cl	NH_3		X
CH_3COONa	$NaOH$	X	
$FeCl_3$	$Fe(OH)_3$		
$CuSO_4$	$Cu(OH)_2$		
$NaCN$	$NaOH$	X	
KNO_3	KOH	X	
KNO_2	KOH	X	
$Al(NO_3)_3$	$Al(OH)_3$		X
$MgCO_3$	$Mg(OH)_2$		
$MnCl_2$	$Mn(OH)_2$		
$Al(OH)_2Cl$	$Al(OH)_3$		
$CaSO_4$	$Ca(OH)_2$	X	
$ZnCl_2$	$Zn(OH)_2$		X
K_3PO_4	KOH	X	

5. Tablo 1'de verilen tuzların anyon ve katyonlarının konjuge asit/bazlarını yazınız.

Çeşitli Tuz Çözeltileri	Anyon ve Konjuge Asiti	Katyon ve Konjuge Bazı
NH_4Cl	Cl^- HCl	NH_4^+ NH_3
CH_3COONa	CH_3COO^- CH_3COOH	Na^+ $NaOH$
$FeCl_3$	Cl^- HCl	Fe^{+3} $Fe(OH)_3$
$CuSO_4$	SO_4^{2-} H_2SO_4	Cu^{+2} $Cu(OH)_2$
$NaCN$	CN^- HCN	Na^+ $NaOH$
KNO_3	NO_3^- HNO_3	K^+ KOH
KNO_2	NO_2^- HNO_2	K^+ KOH
$Al(NO_3)_3$	NO_3^- HNO_3	Al^{+3} $Al(OH)_3$
$MgCO_3$	CO_3^{2-} H_2CO_3	Mg^{+2} $Mg(OH)_2$
$MnCl_2$	Cl^- HCl	Mn^{+2} $Mn(OH)_2$
$Al(OH)_2Cl$	Cl^- HCl	$Al(OH)_2^+$ $Al(OH)_3$
$CaSO_4$	SO_4^{2-} H_2SO_4	Ca^{+2} $Ca(OH)_2$
$ZnCl_2$	Cl^- HCl	Zn^{+2} $Zn(OH)_2$
K_3PO_4	PO_4^{3-} H_3PO_4	K^+ KOH

6. Beşinci soruda belirlediğiniz anyonların konjuge asitlerinin kuvvetli/zayıf olduğunu, doğru olduğunu düşündüğünüz kısma çarpı (X) işaretini koyarak not ediniz.

Çeşitli Tuz Çözeltileri	Anyonun Konjuge Asiti	Kuvvetli Asit	Zayıf Asit
NH_4Cl	HCl	✓	
CH_3COONa	CH_3COOH		✓
$FeCl_3$	HCl	✓	
$CuSO_4$	H_2SO_4	✓	
$NaCN$	HCN		✓
KNO_3	HNO_3	✓	
KNO_2	HNO_2		✓
$Al(NO_3)_3$	HNO_3	✓	
$MgCO_3$	H_2CO_3		✓
$MnCl_2$	HCl	✓	
$Al(OH)_2Cl$	HCl	✓	
$CaSO_4$	H_2SO_4	✓	
$ZnCl_2$	HCl	✓	
K_3PO_4	H_3PO_4		✓

7. Beşinci soruda belirlediğiniz katyonların konjuge bazlarının kuvvetli/zayıf olduğunu, doğru olduğunu düşündüğünüz kısma çarpı (X) işaretini koyarak not ediniz.

Çeşitli Tuz Çözeltileri	Katyonun Konjuge Bazı	Kuvvetli Baz	Zayıf Baz
NH_4Cl	NH_3		✓
CH_3COONa	$NaOH$	✓	
$FeCl_3$	$Fe(OH)_3$		✓
$CuSO_4$	$Cu(OH)_2$		✓
$NaCN$	$NaOH$	✓	
KNO_3	KOH	✓	
KNO_2	KOH	✓	
$Al(NO_3)_3$	$Al(OH)_3$		✓
$MgCO_3$	$Mg(OH)_2$		✓
$MnCl_2$	$Mn(OH)_2$		✓
$Al(OH)_2Cl$	$Al(OH)_3$		✓
$CaSO_4$	$Ca(OH)_2$		✓
$ZnCl_2$	$Zn(OH)_2$		✓
K_3PO_4	KOH	✓	

8. Verilen bilgilerden ve önceki bilgilerinizden yola çıkarak; tabloda belirtilen tuzlardan hangileri **anyonu zayıf baz olan tuzlara** örnektir? Neden?

$Cl^- \rightarrow NH_4Cl$
$Cl^- \rightarrow FeCl_3$
$SO_4^{-2} \rightarrow CaSO_4$
$NO_3^- \rightarrow Al(NO_3)_3$
$Cl^- \rightarrow MnCl_2$
$Cl^- \rightarrow ZnCl_2$

Çünkü kuvvetli asitlerin konjuge bazı anyondur. Ve zayıf baz olmak zorundadır.

9. Yukarıdaki bilgilerden yola çıkarak; tabloda belirtilen tuzlardan hangileri **katyonu yüksek pozitif yüklü (+2,+3 vb.) ve anyonu nötral asidik tuzlara** örnektir? Neden?

$FeCl_3$ (Fe^{+3}, $Cl^- \rightarrow HCl$)
$CuSO_4$ (Cu^{+2}, $SO_4^{-2} \rightarrow H_2SO_4$)
$Al(NO_3)_3$ (Al^{+3}, $NO_3^- \rightarrow HNO_3$)
$MnCl_2$ (Mn^{+2}, Cl^-)
$CaSO_4$ (Ca^{+2}, $SO_4^{-2} \rightarrow H_2SO_4$)

Anyonun nötral olması kuvvetli asitten dolayı anyon olması demektir.

10. Panele katılan öğrencilerden Kemal'in, babası ile ilgili aşağıdaki soruları cevaplayınız:

a. Kemal'in babası, toprakla ilgilenmeyi çok sevmektedir. Bu sebeple, toprağının pH değeri 7,0 olan evinin bahçesinde çeşitli bitkileri yetiştirmeye karar vermiştir. Kemal'in babasının yukarıda verilen bitkilerin her birini bu bahçede yetiştirmek istediğini varsayarsak; her bir bitki için aşağıdaki tabloda verilen maddelerden hangisi ya da hangilerini kullanmak doğru olur?

Toprağa eklenen madde	pH Düşürücü	pH Artırıcı
Amonyum sülfat içeren gübre eklemek	X	
Dolomit eklemek		X
Kireç eklemek		X
Sülfür eklemek	X	

- Yaban mersini → Sülfür, amonyum sülfat
- Ganta çiçeği → Sülfür, amonyum sülfat
- Kalp kalbe karşı → Hepsi
- Leylak → Hepsi
- Kaucuk → Dolomit, kireç
- Kanarya otu → Dolomit, kireç

b. Kemal'in babasının evi **çok nemli** ve **çok güneşli** bir yörede yer aldığına göre; toprak doğru pH değerine getirildikten sonra, hangi bitki en düzgün şekilde yetişecektir?

Yaban mersini

11. Yukarıdaki bilgilerden yola çıkarak; sizce **zayıf baz** ve **zayıf asitlerin** birleşerek oluşturduğu tuz çözeltilerinin asidik mi yoksa bazik mi olacağını başka neleri bilerek cevaplayabilirdik?

Tepkimeye girdikleri orandan.
Hacimlerinden.
Derişimlerinden.
Birine göre diğeri daha baskın olacaktır.

8. Verilen bilgilerden ve önceki bilgilerinizden yola çıkarak; tabloda belirtilen tuzlardan hangileri **anyonu zayıf baz olan tuzlara** örnektir? Neden?

NH_4Cl bu tuzlara örnektir. Çünkü NH_4^+ iyonunun konjuge bazı olan NH_3 zayıf bir bazdır.

9. Yukarıdaki bilgilerden yola çıkarak; tabloda belirtilen tuzlardan hangileri **katyonu yüksek pozitif yüklü (+2,+3 vb.) ve anyonu nötral asidik tuzlara** örnektir? Neden?

$FeCl_3$, $CuSO_4$ bu tuzlara örnektir. Çünkü bu bileşiklerde Fe(+3), Cu(+2) değerlik alır ve Cl^- anyonu da diğerlerine göre daha nötr karakterlidir.

10. Panele katılan öğrencilerden Kemal'in, babası ile ilgili aşağıdaki soruları cevaplayınız:

a. Kemal'in babası, toprakla ilgilenmeyi çok sevmektedir. Bu sebeple, toprağının pH değeri 7,0 olan evinin bahçesinde çeşitli bitkileri yetiştirmeye karar vermiştir. Kemal'in babasının yukarıda verilen bitkilerin her birini bu bahçede yetiştirmek istediğini varsayarsak; her bir bitki için aşağıdaki tabloda verilen maddelerden hangisi ya da hangilerini kullanmak doğru olur?

Toprağa eklenen madde	pH Düşürücü	pH Artırıcı
Amonyum sülfat içeren gübre eklemek	X	
Dolomit eklemek		X
Kireç eklemek		X
Sülfür eklemek	X	

Amonyum sülfat ve sülfür → conta kireği, yaban mersini

Dolomit ve kireç → konşut, karyo otu, leylak

b. Kemal'in babasının evi <u>çok nemli</u> ve <u>çok güneşli</u> bir yörede yer aldığına göre; toprak doğru pH değerine getirildikten sonra, hangi bitki en düzgün şekilde yetişecektir?

Yabanmersini

11. Yukarıdaki bilgilerden yola çıkarak; sizce <u>zayıf baz</u> ve <u>zayıf asitlerin</u> birleşerek oluşturduğu tuz çözeltilerinin asidik mi yoksa bazik mi olacağını başka neleri bilerek cevaplayabilirdik?

Zayıf asit ve zayıf bazda hangisinin daha kuvvetli olduğunu bilmemiz gerekir. Yani ka ve kb değerlerine bakılır.

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Publications

Yalçınkaya, E., Taştan Kırık, Ö., Boz, Y. & Yıldıran, D. (2012). Is case-based learning an effective teaching strategy to remedy students’ alternative conceptions regarding chemical kinetics? *Research in Science & Technological Education, 30*(2), 151-172.

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Tüysüz, M., Yıldıran, D. & Demirci, N. (2010). What is the motivation difference between university students and high school students? *Procedia - Social and Behavioral Sciences, 2*(2), 1543-1548

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